JOURNAL OF THE A·I·E·E·

JULY 1930

PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

PACIFIC COAST CONVENTION, Portland, Oregon, September 2-5, 1930

MIDDLE EASTERN DISTRICT MEETING, No. 2, Philadelphia, Pa., October 13-15, 1930

SOUTHERN DISTRICT MEETING, No. 4, Louisville, Kentucky November 19-22, 1930

MEETINGS OF OTHER SOCIETIES

American Society of Civil Engineers, Annual Convention, Cleveland, Ohio, July 8-11, 1930, (George T. Seabury, Secretary, Engineering Societies Building, 29 West 39th St., New York)

National Electric Light Association

Great Lakes Division, French Lick Springs, Ind., Sept. 25-27, 1930, (T. C. Polk, 20 North Wacker Drive, Chicago, Illinois)

New England Division, New Ocean House, Swampscott, Mass., September 29-October 1, 1930. (Miss O. A. Bursiel, 20 Providence Street, Boston)

American Society of Civil Engineers, Fall Meeting, St. Louis, Mo., (George T. Seabury, Secretary, Engineering Societies Building 29 West 39th Street, New York)

American Gas Association, Atlantic City, N. J., October 13-17, 1930, (Kurwin R. Boyes, Secretary, 420 Lexington Avenue, New York)

JOURNAL of the A. I. E. E.

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

PUBLICATION COMMITTEE

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George R. Metcalfe, *Editor*

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(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

—*Some Activities and Services Open to Members*—

Publications of the A. I. E. E.—The chief publications of the Institute are the JOURNAL QUARTERLY TRANSACTIONS, A. I. E. E. STANDARDS, and the YEAR-BOOK.

The JOURNAL, a monthly publication which every member receives, contains two sections, one devoted to technical papers, and the other to current activities of the Institute and other related subjects of engineering interest. The technical section consists largely of rather complete abridgments of the papers presented at conventions and meetings of the Institute. These are brief enough to enable the reader to keep posted in the various fields of engineering which the papers cover; and complete copies of any paper are sent gratis to the reader who wishes to specialize on any subject. The second section of the JOURNAL is designed to keep members acquainted with the activities of the Institute and with the news of the engineering world in general.

The QUARTERLY TRANSACTIONS contain the papers and discussions at Institute meetings and are the only publications in which they are printed in full. These volumes are designed principally for reference books, and are furnished to members at a very nominal cost. These volumes practically constitute the history of the art of electrical engineering, as they contain papers covering every major electrical development.

The A. I. E. E. STANDARDS which were formerly published in a single book have so increased in volume that they are now divided into more than thirty individual sections and the number is constantly growing. This arrangement gives greater latitude in publishing revisions of any sections promptly, and convenient binders are furnished for filing all the individual sections under one cover. An index for the complete set is also available. The standards are supplied to members at a very small cost.

The YEAR BOOK is published annually and contains an alphabetical and a geographical list of members corrected to January first each year. It also includes a section giving general information about the Institute, the Constitution, By-Laws, Code of Principles of Professional Conduct and the Annual Report of the Board of Directors. The Year-Book is sent free to members upon request.

Scope of Papers—Institute papers should present information which adds definitely to the theoretical or practical knowledge of electrical engineering and may be derived from activities in any of its branches. Acceptable subject matter is as follows: New theories or new treatments of existing theories; Mathematical solution of electrical engineering problems; Researches, fundamental or practical; Design of equipment, and of electrical engineering projects; Engineering and economic investigations; Operation and tests of electrical equipment or systems; Measurements of electrical quantities; Electrical measurement of non-electrical quantities; Applications of electricity to industrial or social purposes; Education; Standardization; Cooperative engineering organizations; Ethical and social aspects of the profession.

Employment Service.—The employment service is a joint activity administered by the Civil, Mining, Mechanical, and Electrical Engineering societies and is available to the membership of these societies. Branches of this Department are located in Chicago and San Francisco, the main office being located at the societies headquarters in New York. The service is designed to be mutually helpful to engineers seeking employment, and concerns desiring to secure the services of engineers. This department is financed by contributions from the societies maintaining it and from beneficiaries of the service. Further details will be furnished on request to the Managers of the Employment Service at the main or branch offices, addresses of which will be found elsewhere in this issue.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLIX JULY, 1930 Number 7

A Message From the President

Lecturers for the Institute

DURING the past year there has been proposed many times at Section meetings and elsewhere* the question of scheduled addresses offered by prominent Institute members, upon the invitation of various Sections of the Institute, following some effective plan conserving the time and effort of the speaker, and as convenient as may prove possible for an efficient schedule for the Sections. It has met with favorable and cordial response in every case. Apparently it is one of the more important things that the Institute can do at the present time which will be of distinct benefit to a majority of its membership. The plan is under active consideration at the present time, and if approved at the Section Delegates Conference and by the Board of Directors, it may soon become an active influence in Institute development. It is naturally a matter which must be handled by a small central committee to coordinate and arrange details which must be decided and announced in a prompt and effective manner. Such a committee will naturally include the Assistant National Secretary and the Chairman of the Sections Committee of the Institute.

The experiences of the past year, in visiting practically all Sections of the Institute, lead to the following suggestions in the hope they may be of service in establishing such a plan and possibly placing it in operation promptly.

(a) As soon as possible after the election of new Section and District officers, any Section desiring to be scheduled for an Institute Lecture should make application to Headquarters through its District Vice-President.

(b) Information should be forwarded as promptly as possible from Headquarters to the Section making application, this information to give scheduled date, name of speaker, subject, etc., in order that printing of yearly program of the Section may not be delayed.

(c) The financing of each schedule,—possibly two or three the first year and as many as five or six later,—may be carried out as follows: All travel expenses to be borne by the Institute; all local expenses to be borne by the Section; a committee of the Section to meet the lecturer at the train and care for his comfort as its guest until his departure—the lecturer to contribute his time and effort in the interests of the Institute and his profession.

(d) It is hoped that each year some of the smaller Sections will be placed on the schedules of the President and of each of the lecturers. The small Sections need the stimulus, and the speakers will find great satisfaction in their reactions.

(e) With not more than ten or fifteen Sections on any one schedule, and at the rate of five meetings per week, it will require three weeks (more or less) of the time of a lecturer to complete his schedule.

(f) To be selected to serve as an Institute lecturer should be recognized as a distinct honor.

Harold B. Smith
President.

*JOURNAL, A. I. E. E., Vol. XLVIII, p. 659, and Vol. XLIX, p. 1.

Some Leaders of the A. I. E. E.

Lewis Taylor Robinson, Engineer in Charge of the General Engineering Laboratory, General Electric Company, at Schenectady, New York, Associate Member of the Institute 1904, Fellow 1912, Manager 1913-16 and Vice-President 1916-17, 1920-21, was born in Springfield, Mass., October 20, 1868. At the age of seventeen he joined the Thomson-Houston Electric Company at Lynn and was presently put in charge of the Standardizing Laboratory inaugurated by that Company. From that day to this he has grown with the electrical industry, primarily in shaping its standards and in initiating new developments. Union University conferred the degree of Doctor of Science on him in 1929 as "a student in the truest sense of the word."

After a short venture of his own in 1891, in the electrical business in Boston, he became associated in 1893 with the Schuyler Electric Company, at Middletown, Conn. This company was at the time affiliated with the newly formed General Electric Company, and soon was absorbed by it. In 1896 Doctor Robinson went to Schenectady and was placed in charge of the Standardizing Laboratory there. Later when the Consulting Engineering Laboratory and the Standardizing Laboratory were joined to form the General Engineering Laboratory he was made engineer in charge.

Under his administration the Laboratory has established and maintained a complete set of electrical standards for the company and has contributed many developments to the art. Notable among these were electrical measuring instruments and instrument transformers, the oscillograph, means for determining the magnetic properties of iron, early radio developments, power mercury arc rectifier apparatus, and the photophone—a system of motion pictures with sound. In connection with these and other developments Doctor Robinson has been granted a considerable number of patents and he has contributed numerous papers before National engineering societies.

In addition to having served as Manager and Vice-President, Doctor Robinson has served the Institute in various other capacities. He has been a member of the Standards Committee for many years and served as Chairman in 1919-20. He was one of the Institute representatives on the Joint Conference Committee responsible for founding the present American Engineering Council. At the present time, he is one of the Institute delegates to the American Standards Association. During June 1930, in company with four other delegates, he represented the Institute at the World Power Conference in Berlin. Among other Institute Committees on which Doctor Robinson has served in the past are: Meetings and Papers, Editing, Principles of Professional Conduct, Technical Lectures, Electrophysics, Sections, Development, Coordination, General Conference Committee of the Founder Societies, Edison Medal, Storage Batteries, and Instruments and Measurements.

One of Doctor Robinson's major interests has been in connection with the procedure for and the development of standards for the electrical industry. He has served on numerous standardization committees both within and without the Institute and at present is a member of a special committee appointed by the Electrical Advisory Committee of the American Standards Association to recommend a unified system of standardization within the electrical industry.

Doctor Robinson has done considerable work as a member of the United States National Committee of the International Electrotechnical Commission, especially as a member of the Committee on Rating and its Subcommittee on Temperature Rises. During the Summer of 1929 he attended meetings of these committees in London and also their meetings and the Plenary Meeting of the I. E. C. in Berlin, Copenhagen, Stockholm, and Oslo during June and July 1930.

Doctor Robinson is a Fellow of the American Physical Society, and a member of the Society of Motion Picture Engineers, Society for Promotion of Engineering Education, American Association for the Advancement of Science, and the Society of Engineers of Eastern New York. He is a member of the Development and Research Subcommittee of the Joint General Committee of the National Electric Light Association and Bell Telephone System which deals with the physical relations between electric light and signal circuits. He is also a member of the Mohawk Club of Schenectady.

His chief diversion is music. A performer on several instruments himself, he takes keen delight in playing with an orchestra or band, and is a most capable director. He also finds much pleasure in his farm-home near Schenectady, in his home laboratory work, and his rather complete library of technical books and periodicals.

To his many friends in the Institute, Doctor Robinson is probably best known for his many years of devotion to the work and problems of the Institute, for his ability to accurately characterize a situation, and for his ready wit and humor.

Light-Beam Train Control

A new device described in *Science News Letter* is being tried out over a stretch of several hundred miles of the German State Railways, between Berlin and Munich. From a small searchlight on the front of the locomotive a narrow beam of light is thrown upward all the time the locomotive is in operation. A ring of light-sensitive cells are located around the searchlight lens. When the train comes to a signal post, the mirror on the post reflects the light back to one of the cells. This starts an electric current, which makes a visible signal in the engine cab, and remains until the engineer acts on it, or, if he does not respond promptly, the train is stopped automatically.

Abridgment of

An Electron Tube Telemetering System (Part I)

BY A. S. FITZGERALD[1]

Member, A. I. E. E.

***Synopsis.**—The paper describes a varying frequency telemetering system which employs an electron tube beat frequency oscillator, the frequency of which is controlled by a small condenser mounted upon the movement of the instrument, the reading of which is to be transmitted. The reading is reproduced at the receiving end by a frequency meter having a scale corresponding to that of the transmitting meter. When furnishing a single indication, the outstanding feature of this system is that except for the movements of the transmitting and receiving instruments themselves, there are no contacts or moving parts. The system does not require instruments of unusual type, and it is not limited only to the transmission of electrical readings, but may readily be applied to any deflection instrument; for instance, indicating pressure, temperature, etc. The accuracy of the system is not affected by changes in the impedance of the channel of transmission. The system is equally suitable for transmission over wire conductors or by means of carrier current or radio.*

A method which uses automatic telephone type selectors at transmitting and receiving stations and furnishes a number of telemetering indications over a single conducting circuit or carrier-current channel is also described. A feature of this system is that no synchronizing channel or synchronous power is required. By a system of impulses, the selectors automatically establish and maintain synchronism.

A field installation which has given satisfactory results is described.

Introduction

It is becoming increasingly desirable that the load dispatcher of a modern power network be fully informed as to the load conditions at remote parts of the system. Several different telemetering systems for varied applications have been developed. These have special advantages and limitations according to the kind of telemetering indications required and the channel of transmission to be used.

This paper describes an attempt to furnish a method of telemetering of more general scope than existing systems, and one which may lead to more standardized practise. The aim is to develop a system in which similar terminal equipment may be suitable for telemetering either single or multiple indications, and visual or graphic, totalizing or integrating, electrical or non-electrical readings; and further, which might permit of transmission either by special conductors, telephone circuits, or carrier current, whichever channel may be most readily available or most economical for each case.

A frequency can be transmitted through any of these channels and for that reason, this system is based upon the varying frequency principle. Recent developments in electron tubes and circuits make it possible to produce, control, and indicate a variable frequency without the rotating apparatus that has hitherto been necessary to frequency telemetering systems.

Telemetering Single Instrument Reading Over Conducting Circuit

Fig. 1 shows the general arrangement employed; a small condenser is attached to the movement of the instrument of which the reading is to be telemetered. This condenser is connected to an oscillator so that the frequency of the latter varies according to the meter position.

A second oscillator, operating at a frequency close to that of the first oscillator, has a fixed condenser, and therefore furnishes a constant frequency. A beat frequency is set up by these two oscillators, and this is detected by means of a third vacuum tube.

The beat or telemetering frequency is transmitted over the connecting line to the receiving station, where it operates a direct-reading frequency meter furnished with a scale corresponding exactly with that of the distant instrument. It will indicate at all times exactly the position of the remote instrument, and will follow all changes and fluctuations. It is not affected by changes in signal strength, provided it receives more than the minimum power necessary for operation. Thus, any changes in the impedance or leakage resistance of the line do not affect the accuracy.

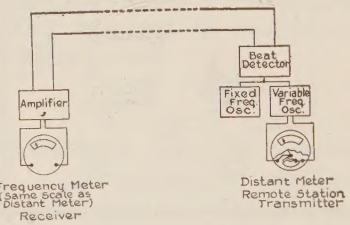

Fig. 1—Transmission Over Wire Conductor

This scheme, therefore, actually transmits the deflection of the instrument. It need not be restricted to electrical meters, but may be applied to other types of instruments.

Carrier-Current Transmission

Fig. 5 shows a schematic diagram of the general arrangement for carrier-current telemetering. The beat frequency is applied in the regular way, to the modulator instead of to a microphone speaking circuit.

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1. Engg. Dept., RCA. Victor Company, Inc., Camden, N. J.

Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Can., June 23-27, 1930. Complete copy upon request.

The carrier-current generator consists of the usual arrangement of master oscillator and power amplifier. There is thus sent out over the line a carrier wave of steady frequency, modulated by an audio frequency varying according to the position of the instrument which is being telemetered.

At the receiving end, the carrier is demodulated and the audio signal amplified. The amplified signal is then taken direct to the frequency meter which reproduces the position of the distant instrument. Especially will it be noted that again the signal strength (provided it be sufficient to energize the apparatus) has no effect upon the accuracy of the indication.

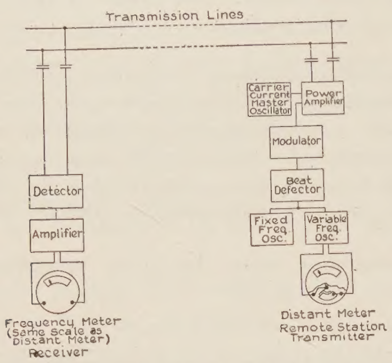

FIG. 5—TRANSMISSION BY MEANS OF CARRIER CURRENT

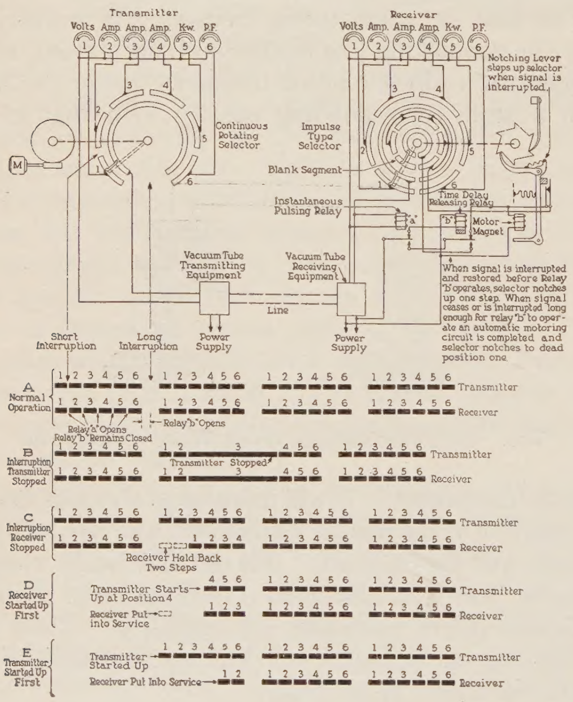

FIG. 8—METHOD OF SYNCHRONIZING MULTIPLE TELEMETERING SYSTEM

MULTIPLE TELEMETERING

For load dispatching and other important services where it is desirable for the operator to be able to see at a glance the state of the system in general, an arrangement has been devised whereby a number of instruments at one station may be indicated in the load dispatcher's office over a single telemetering channel employing one transmitting equipment and one receiver. This may be carried out with equal convenience over either a wire line or over the power conductors by means of carrier current.

According to this system, there is provided at the receiving station a continuously operating selector which automatically connects for a brief period each instrument,—one after the other,—to the telemetering transmitter.

At the receiving station there is installed an equal number of frequency meters, identical in construction but each bearing a scale representing the corresponding instrument at the remote station. A second selector, associated with the receiver, is arranged to connect each receiving instrument to the telemetering receiver during exactly the correct period at which the corresponding remote meter, controlling the indicating frequency, is connected by the transmitter selector to the telemetering apparatus. The receiving instruments which are employed with this system of telemetering have movements of the type which retain their position when deenergized. Thus, when they are operated in this manner, we get the following result: Each instrument indicates at all times the reading shown when it was last connected to the telemetering circuit. At regular intervals, each meter is corrected. The result will be that all of the instruments, will show at any time the state of the power system not more than a few seconds before. Thus, a survey of the whole set of meters will furnish (and very accurately indeed) as good an idea of the operation of the distant station as if one could see the remote instruments in actuality.

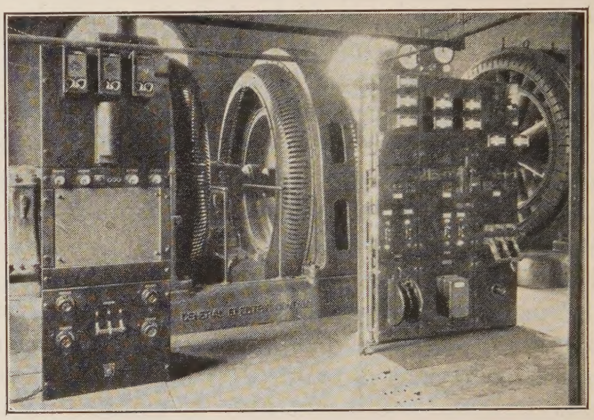

FIG. 9—INSTALLATION AT AMSTERDAM

It is clearly necessary to synchronize the selector at the receiving station with that at the transmitter. One feature of this scheme which is of special interest is the fact that, unlike many existing methods of synchronizing, it does not require a special channel for this purpose. No extra conductors or additional carrier-current circuit are necessary; nor is it necessary to perform any special operation when in order to synchronize the two selectors the apparatus is placed in service. It is no more difficult, therefore, to operate multiple instru-

ment telemetering over carrier or radio than over a wire line.

Fig. 8 shows how this has been accomplished.

Description of Apparatus

In order to study the operation of this system under service conditions, an installation has been made in the neighborhood of Schenectady. Instrument readings in a railway substation at Amsterdam, N. Y., and at another substation at Glenville, are transmitted to a receiving station near Schenectady by means of carrier current.

Fig. 10—Installation at Glenville

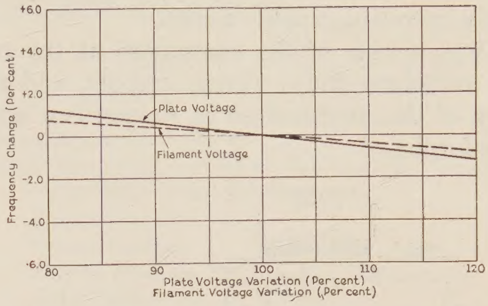

Fig. 15—Beat Oscillator Characteristics

Fig. 9 shows the apparatus as installed at Amsterdam; a view of the Glenville installation is shown in Fig. 10.

Fig. 15 shows the effect upon the beat frequency of voltage variation of the plate and filament supplies.

(Part II)

Synopsis.—*This section of the paper discusses the problems of totalizing, graphic recording, and the telemetering of watthour or integrating meters, and describes a new thyratron circuit which furnishes a d-c. current directly proportional to the frequency at which the circuit is excited. By means of this circuit, a number of varying frequency telemetering signals may be totalized by adding the d-c. outputs of the thyratron circuit; the resultant current is then proportional to the sum of the several frequencies.*

The use of this thyratron circuit to furnish totalized indications in a field installation is described.

In addition, the problem of transmitting watthour indications is generally discussed. A method of transmitting watthour readings by means of the electron tube varying-frequency system is described. Signal frequencies proportional to individual dial readings of the watthour meter are sent out. The advantages of this method are that by sending out individual dial readings, high accuracy is obtained; and when the dial reading of a watthour meter is transmitted, the telemetering channel is not required except when the readings are actually being observed.

* * * * *

What is required for furnishing totalized indications with a varying frequency telemetering system is an instrument or its equivalent which will give a reading proportional to the sum of several different frequencies. Totalizing ammeters and wattmeters can readily be constructed; these are known as "torque" type instruments. Readings of d-c. current can readily be totalized by adding the several currents in a common circuit, and connecting them to a single ammeter. Wattmeter readings can as easily be totalized by mounting two or more meter movements on a common shaft so that the resultant torque is the sum of the contributing torques.

But frequency meters do not furnish a torque proportional to the frequency. These instruments are usually of the "position" type and do not lend themselves readily to totalizing. Therefore, in order to totalize several frequency indications, there is employed an electron tube circuit utilizing tubes of the thyratron type, which furnishes a direct current proportional to the frequency signal. The several d-c. currents may then easily be totalized.

Thyratron Frequency Indicating Circuit

The fundamental principle of this circuit is shown in Fig. 1. During each a-c. cycle, a condenser is first charged through a d-c. measuring instrument from a fixed source of d-c. voltage, and then discharged. The current read by this instrument is proportional to the condenser capacity, the d-c. supply voltage, and the frequency; therefore, with a fixed condenser and constant voltage, the current as shown in Fig. 2 is directly proportional to frequency.

While the operation of the form of circuit shown in Fig. 1 is more readily explained, a modification developed by Mr. B. D. Bedford has superior operating characteristics.

If a source of power of sufficiently close regulation is not available, the measuring instrument may be compensated so that reasonable variations in the supply voltage will cause no error. Fig. 4 shows Mr. Bedford's improved circuit used in conjunction with an instrument so compensated.

With this thyratron circuit, any number of incoming frequencies, each a function of a meter deflection, may readily be added together by merely connecting all three thyratron circuits so that the total current flows through a common meter. Three such signals are shown totalized in this way in Fig. 7, each individual

reading being given by three corresponding meters, and the total shown by a fourth instrument.

This thyratron circuit has the additional advantage, of being capable, with a low plate voltage, of much larger power output than a vacuum tube amplifier, and of readily operating graphic meters.

Fig. 9 is a view of the equipment at the receiving station at Schenectady; visual, graphic, and totalized readings of the instruments in Amsterdam and Glenville are furnished.

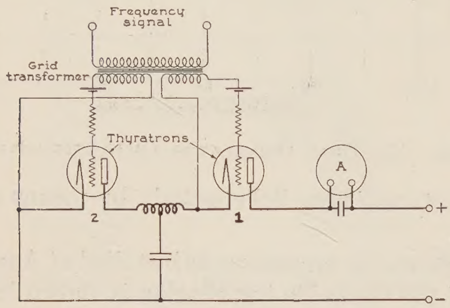

Fig. 1—Principle of Thyratron Frequency Indicating Circuit

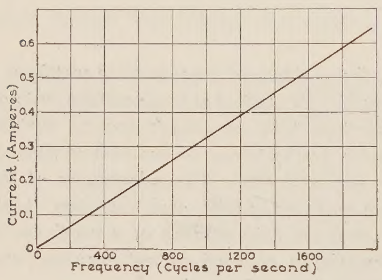

Fig. 2—Operation of Thyratron Frequency Indicating Current

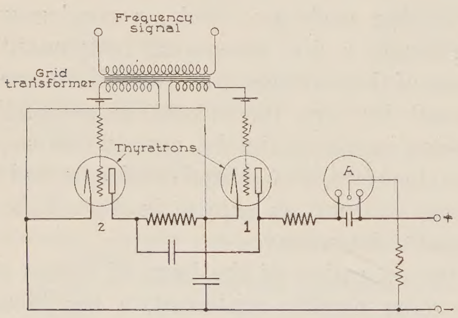

Fig. 4—Compensation for Voltage Variation

Watthour Indications

There are two definite methods of telemetering watthour readings: one, to transmit a signal proportional to the watts and integrate this at the receiving end, has usually been employed up to the present. But if we do this, we must have the exclusive use of the carrier current or other channel by means of which the signal is transmitted; and if this channel be interrupted, due to a system outage or other emergency, the integrated reading will be in error by an amount equal to the energy registered by the meter during the period of the outage.

Thus, it may be preferable to transmit instead, a frequency proportional to the kilowatt-hours already integrated at the transmitting end, which can be done by means of the arrangement shown in Fig. 8.

With such a scheme, we do not require the exclusive

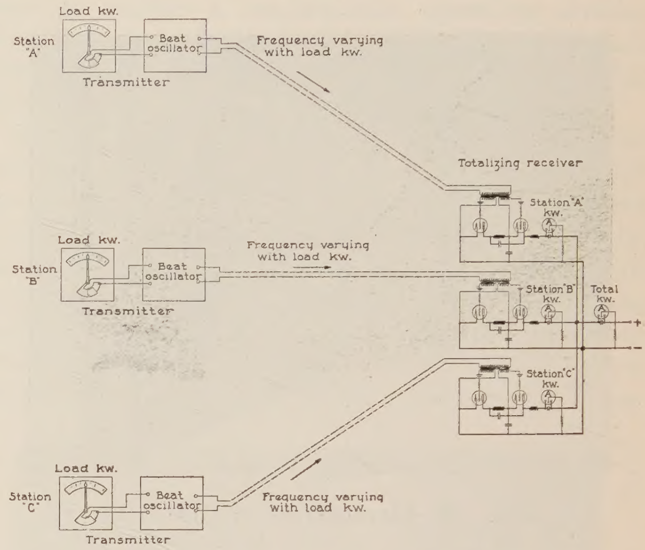

Fig. 7—Totalizing Connections

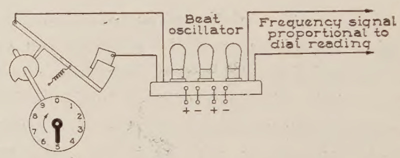

Fig. 8—Principle of Watthour Meter Transmission

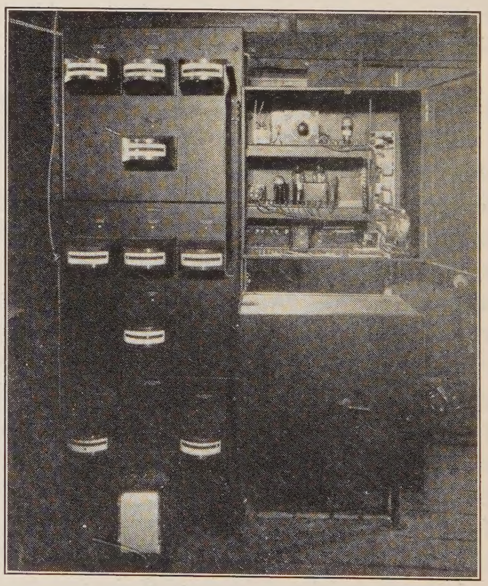

Fig. 9—View of Modified Receiving Installation

use of the telemetering channel. We need occupy it only during the period when the readings are actually being observed. In a continuous automatic multiple telemetering system of the type described in Part I of this paper, any number of watthour meter dials may be included in the complete series of indications.

Abridgment of

Vertical Shaft 25,000-Kv-a., Synchronous Condensers

25-Cycle, 500-Rev. per min., Outdoor Type Units for Toronto Leaside Transformer Station

BY H. A. RICKER,* Non-Member
J. R. DUNBAR,* Member, A. I. E. E.
and
R. E. DAY* Non-Member

Synopsis.—*This paper is descriptive of the 25,000-kv-a., 13,200-volt, 25-cycle, 500-rev. per min., vertical shaft, outdoor type, self-starting, synchronous condensers installed in the Toronto-Leaside Transformer Station, of the Hydro-Electric Power Commission of Ontario. Some of the special problems encountered because of the vertical-shaft, outdoor type arrangement, are discussed. In the appendix, the automatic starting and stopping sequence is given, with a comparison between the results obtained by using open-circuit transition and the results to be expected by using closed-circuit transition.*

The following table of contents explains the plan of presentation:

1. *Introduction.*
2. *Mechanical Design.*
3. *Type of Condenser.*
4. *General Arrangement.*
5. *Weights and Dimensions.*
6. *Shipment and Installation.*
7. *Detail Description—Stator.*
8. *Detail Description—Rotor.*
9. *Detail Description—Brackets, Bearings, and Housing.*
   Upper Bracket and Bearings.
   Thrust Bracket.
   Thrust Bearing.
   Exciter Bearing.
   Speed Relay.
   Housing.
10. *Maintenance.*
11. *Ventilation.*
12. *Bearing Protection.*
13. *Fire Protection.*
14. *Electrical Protection.*
15. *Ground Detector.*
16. *Calculated Electrical Characteristics.*
17. *Starting and Stopping Procedure.*
18. *Operation.*
    Appendix.

DURING the past year, one of the outstanding installations of electrical equipment in Canada, has been that of the Hydro-Electric Power Commission of Ontario, at the receiving end of their transmission line from the Gatineau. The installation of the two 25,000-kv-a., 13,200-volt, 25-cycle, 500-rev. per min., vertical-shaft, outdoor type, self-starting synchronous condensers forms an important part of the development.

Fig. 1 illustrates the general arrangement of a unit on its foundation, while Fig. 4 shows in detail a cross-section of a condenser, complete with bearings, exciters, and housing.

The main features noticed in the figures are the vertical-shaft design, the basement under the machine, and the enclosing housing.

While vertical shafts are most common among water-wheel-driven generators and on pump motors, so far as the authors are aware, synchronous condensers have always retained horizontal shafts. Owing to the fact that vertical-shaft design was chosen a great deal of astonishment has been shown regarding this installation.

The basement which forms part of the foundation structure for the condenser and for the crane runway rail required very little enlargement to provide ample space for all auxilliary apparatus, such as oil pumps, oil to water coolers, switching, oil storage, carbon dioxide protection apparatus, and other miscellaneous items. The excavating for this basement was not difficult, as the soil was all clay.

The enclosing housing, above ground, not only protects the unit from the weather, but also forms the necessary enclosure for controlling the ventilation. Incorporated in this housing are air filters. Dampers also are arranged not only in the housing, but in the housing floor and, for various purposes, in the condenser frame. All dampers are provided with automatic control. The Kingsbury thrust bearing illustrated on Fig. 6 is located below the condenser rotor and is of an uncommon design; it serves the purpose of a journal bearing as well as of a thrust bearing. A feature to permit easy starting is also incorporated.

Two exciters to provide quick response excitation are mounted under the thrust bearing deck.

One gantry crane with one double hook was ample to unload, handle, and install all parts. The paper illustrates the method by which the 80-ton rotor was up-ended and lifted from the car; also the method by which the 80-ton stator shipped in horizontal position was lifted and turned to a vertical position in being removed from the car.

Letter *N*, in Fig. 1, designates the only other major item used in assembly and maintenance; it illustrates a truck on a track, by means of which the combined

*All of the Canadian Westinghouse Company, Limited, Hamilton, Canada.

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exciters, rotors and stators, and exciter support bracket, may be moved in and out from under the thrust bearing deck.

The process of rotor removal with this unit is to remove first the two exciters and journal bearing as above described, and then to lower the main rotor into the space vacated by the exciters, the thrust bearing and deck being lowered with the rotor. This arrangement provides ample clearance to rewind a stator completely if necessary.

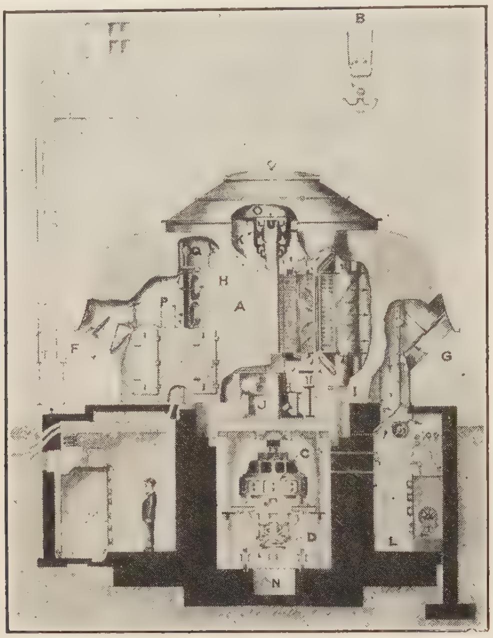

Fig. 1—General Arrangement of Unit on Foundations

A 25,000-Kv-a. condenser 500 revolutions per minute	I Damper for basement heating
B 80-Ton gantry crane	J Spherical thrust bearing
C 150-Kw. 125-volt main exciter	K Upper guide bearing
D 30-Kw. 250-volt pilot exciter	L High-pressure oil pump for starting
F Main incoming air damper	N Truck for handling exciters
G Main outgoing air damper	O Threaded hole for rotor lifting eye
H Recirculating air damper	P Air filters
	Q Current transformers

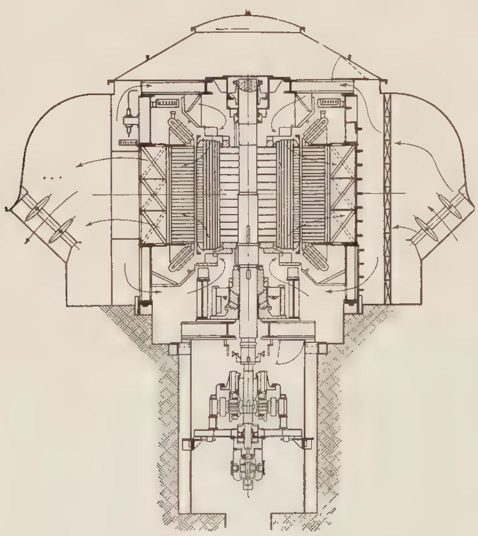

Fig. 4—Cross-Section of Unit

The study that produced the adopted arrangement had out-of-doors design as its corner stone. Other foundation stones were economy of design, economy of space occupied, and convenience of maintenance. Other features stressed were protection, both mechanical and electrical, and automatic control.

When in operation the unit is absolutely protected from the weather. It was November 1929 when the first unit was put into service; during the period of operation, including the rather severe winter, absolutely no inconvenience has been experienced from combinations of wind, rain, sleet or snow. An almost insignificant amount of inconvenience has been experienced for purposes of maintenance; no more inconvenience was experienced during installation than is often incurred on indoor installations when powerhouse construction is concurrently carried on.

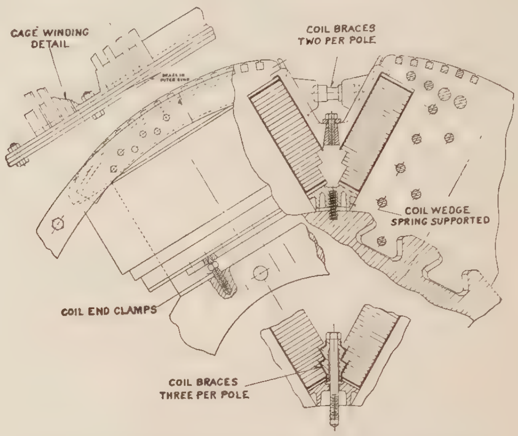

Fig. 5—Some Details of Rotor Design

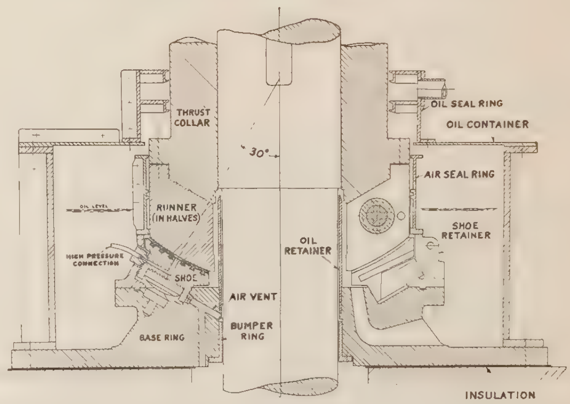

Fig. 6—Cross-Section of Kingsbury Spherical Bearing

Only in case the upper journal bearing or the rotor has to be removed is it necessary to expose even a portion of the top of the machine, even then, only a small cover need be removed; this, when the journal bearing is taken out to lower the rotor, exposes a hole only large enough to pass the crane hook and block. This exposes only the center of the rotor, while the stator remains fully protected. We leave it for the critics to discuss the relative merits of an outdoor horizontal shaft type housing.

For economy of design, one might compare an 80-ton horizontal shaft rotor with this vertical design. Compare the spider design, the stiffness of shaft and the

bearing design. As for stator design, there is little preference.

The actual ground area occupied by this vertical unit is perhaps not much more than half of that covered by a horizontal unit of the same rated capacity. What other space would be occupied by the controls, pumps, etc., previously ennumerated? What extra crane capacity would have to be provided to handle the parts, especially at such time as the rotor had to be removed from the stator? To one who understands the construction the convenience for maintenance here is self-evident. The car removes, intact, the two exciters and their bearing bracket from the pit under the main rotor. A ring-key, bolted into place around the shaft under the thrust deck, serves to tie the thrust deck and bearing to the rotor. The removal of the top journal bearing permits attachment of the crane to the shaft, and, as the rotor is lowered, slots in the foundation walls permit the thrust deck to be lowered to the floor. Except for the removal of the small top cover, the housing is entirely undisturbed. A few men and a few hours are all that is required to lower the rotor out of the stator and that with a minimum amount of man handling. What an awkward job is presented in the removal of an 80-ton rotor from a horizontal stator!

The mechanical and electrical protection is not unusual, but it is complete. The automatic control provided some unusual problems. Mechanical protection is assisted by the use of air brakes, easily applied to vertical units. When first designed, it was intended that the four air brakes should be used as jacks to lift the rotor, but because it was so convenient to lift the rotor with the crane that idea was later abandoned. Owing to the additional equipment necessary brakes are seldom, if ever, arranged to stop horizontal units.

The stator design presented few unusual problems. The diamond ends of the armature coils are formed so that the continuity of the inner and outer surfaces form true surfaces of frustums. This makes applicable the angular support form of bracing applied.

The rotor required careful study; some of the features of design are shown in detail in Fig. 5; bracing between coils to eliminate deformation due to tangential stresses had to be made unusually strong. The greater portion of this tangential load is transferred to the pole tips, and nickel steel pole punchings are used at the points where these braces are applied. The remainder of the tangential load is carried by the three-wedges-per-pole, which are secured by alloy steel bolts to the spider. The field coils are provided with springs under the coils, in order that the washers and coil insulation will be held tight at all times and after the usual shrinkage has taken place.

The starting squirrel-cage winding is of the "angle weld," construction. The end-rings are laminated of three thicknesses of hard-drawn copper bar.

Buried Distribution Type Transformers

BY C. E. SCHWENGER[1]

Associate, A. I. E. E.

Synopsis:—*This paper describes the preliminary tests, design, and insulation of distribution transformers located underground, instead of overhead on poles, and in direct contact with the earth, in contrast with those located in expensive underground vaults. The preliminary tests indicating the feasibility of such a method of installation are outlined. The special transformer case used, including such details as the water and air-tight inner cover with pressure seal, is described. Buried oil cut-outs of special type where required are also described. The ease of replacing defective transformer coils is also indicated.*

TRANSFORMERS of moderate sizes on distribution systems are usually mounted overhead on poles, or on platforms, and are also installed in vaults underground. They may also be buried directly in the earth without the use of vaults. It is the purpose of this paper to show that transformers so buried have a good load carrying capacity due to the excellent heat conducting properties of the surrounding earth.

In cities having fine residential sections the mounting of transformers on poles is apt to provoke complaints from the public, due to their unsightly character. The size of transformers which may be mounted on poles is also limited owing to their weight. This is particularly the case where transformers are designed for 25-cycle operation. The alternative has usually been to install transformers in underground vaults at a greatly increased capital cost due largely to the cost of the vaults and the special equipment required for underground operation of the transformers.

Experiments with buried transformers were begun in Toronto in 1924. To approximate the worst conditions of soil likely to be encountered, a 25-kv-a. 2400/120-240-volt 25-cycle transformer of regular pole mounting type, having a cylindrical sheet steel tank 47 in. high and 21 in. in diameter, was buried in very dry sand, contained in a box which measured six by six by four feet. The transformer was buried in the center of this box to within 5 in. of the top of the case; thermometers were inserted in the top oil of the transformer as well as in the sand at distances of 6 in., 12 in., and 24 in. from the transformer case. The thermometer bulbs in the sand box were located 12 in. below the sand surface.

The core loss of the transformer was 130 watts, and full-load copper loss at 75 deg. cent. was 543 watts.

1. Engineer of Distribution, Toronto Hydro-Electric System, Toronto, Ont., Can.

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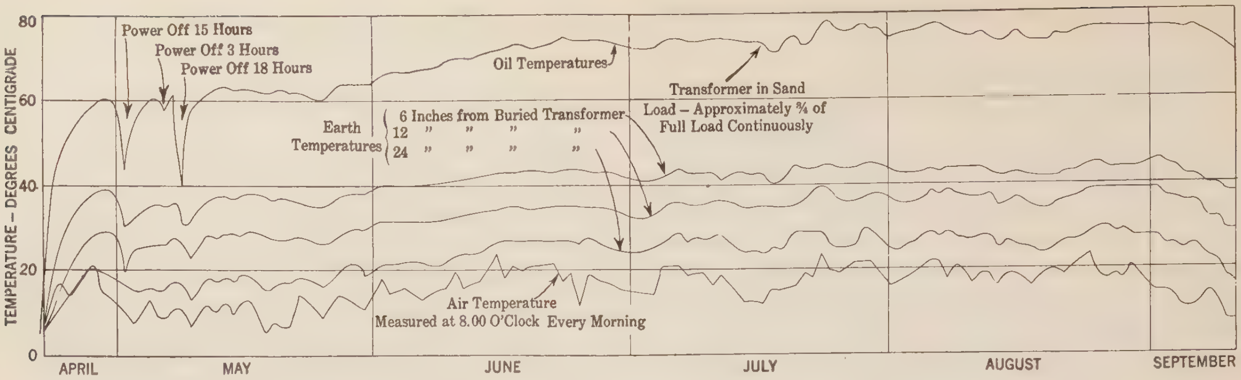

FIG. 1

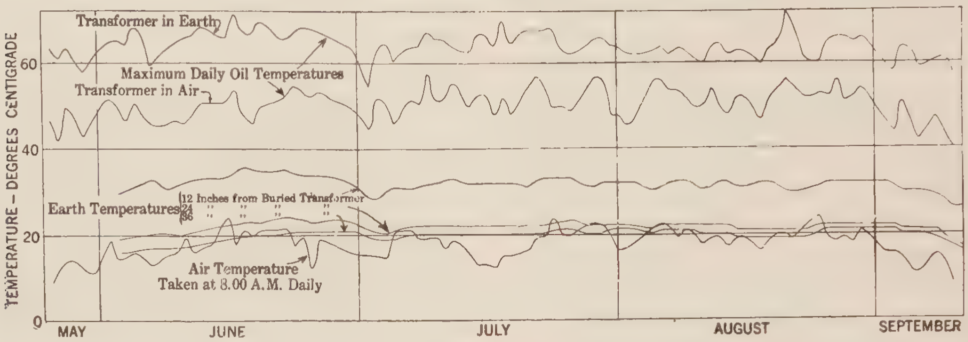

FIG. 2

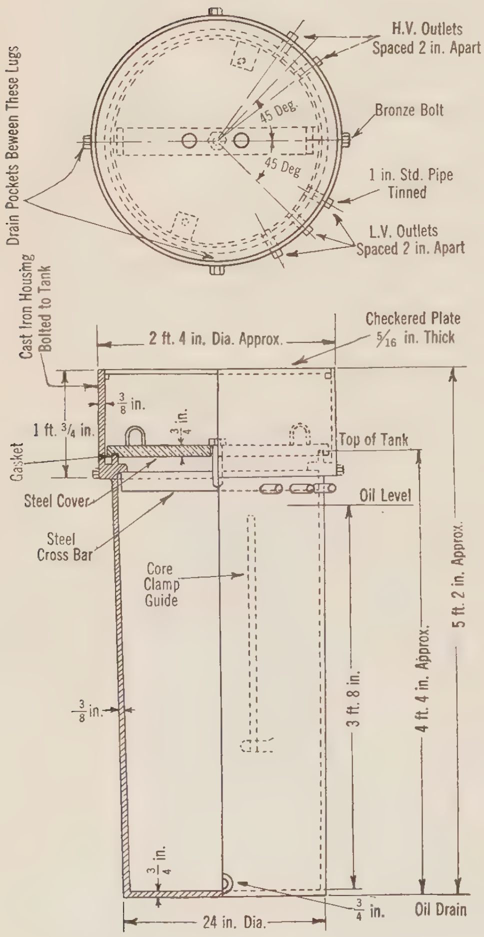

FIG. 3—CAST IRON TANK FOR 37½-KV-A. 25-CYCLE BURIED TRANSFORMER

The test was made indoors so that the sand would remain constantly dry. A continuous load of ¾ rated full-load current was placed on the transformer. This was short-circuit current at reduced voltage without any excitation on transformer. The loss producing heating was therefore about 308 watts.

The results of this test, taken over the months of May, June, July, and August 1924, are shown in Fig. 1. It will be seen that the temperature readings of the oil in the transformer and in the sand vary almost directly with the atmospheric temperature. The oil temperature is almost uniformly about 50 deg. cent. higher than the atmosphere. Six inches out from the case, the temperature is 20 deg. cent. above that of the air; and 12 in. out, it is 13 deg. cent. higher; at 24 in. out, it is only 6 deg. cent. higher. This test shows that a transformer would give up its heat in the poorest kind of soil, and that the temperature rise with respect to the ambient air temperature would be constant.

Also in 1924, a second test was made on two transformers of similar characteristics. One was buried out-of-doors, exposed to rain, and the other was installed on an adjacent cedar pole. The loads on both transformers were identical. The load cycle was as follows,—20 hr. at 50 per cent full load, 4 hr., 125 per cent full load daily except Sunday, when the load was 24 hr. at 50 per cent of full load. The transformers were both excited at full voltage. Fig. 2 shows results of this test. It will be seen from the curves that the buried transformer showed greater heating than transformer operating in air, there being a difference in temperature of about 15 to 20 deg. cent. The temperature curve for

the buried transformer shows dips which approach the temperature curve of the other transformer. This was due to increased soil moisture following rain, under which condition, heat transfer from the buried tank to soil was

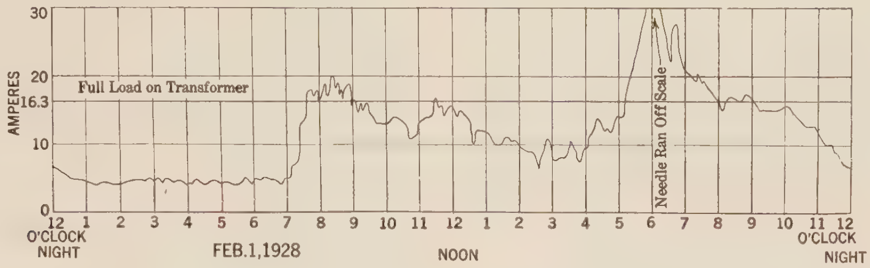

Fig. 4—Characteristic Daily Loading on Transformer

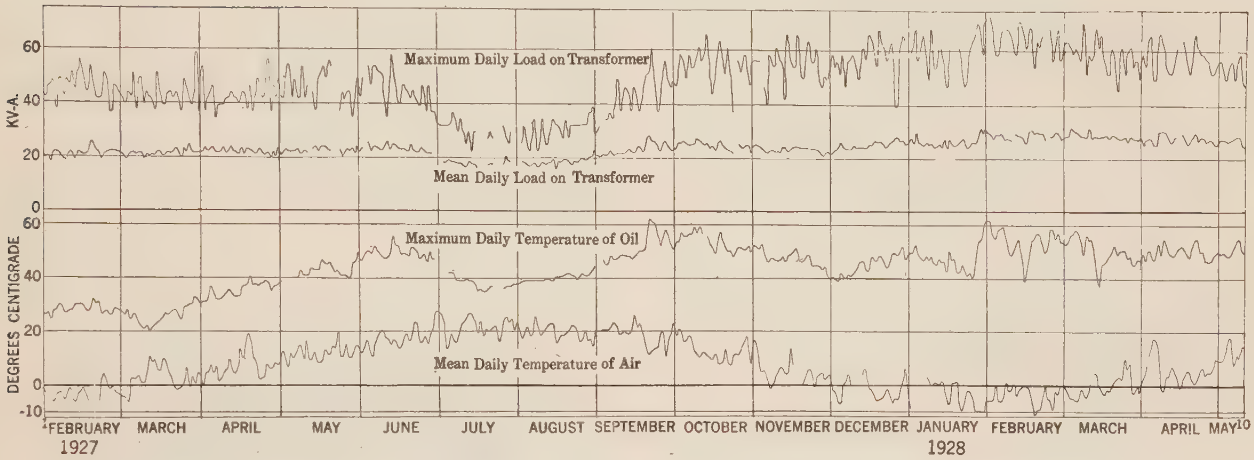

Fig. 5

Fig. 6—Underground Distribution Transformers in Cast Iron Tanks—Side View

greatly improved with a resulting lower oil temperature in the transformer.

These tests led to the design of a transformer case as shown in Fig. 3. Since size and weight reduction are not of importance when a transformer is buried, the case has been made somewhat larger than for a corresponding transformer for pole mounting. This transformer is rated at 37½ kv-a. Two of these units were installed in May 1925 and since then have been in continuous service. They are located about 500 ft. apart, behind the sidewall on the boulevard in a residential district. They are connected in parallel on the same low-voltage

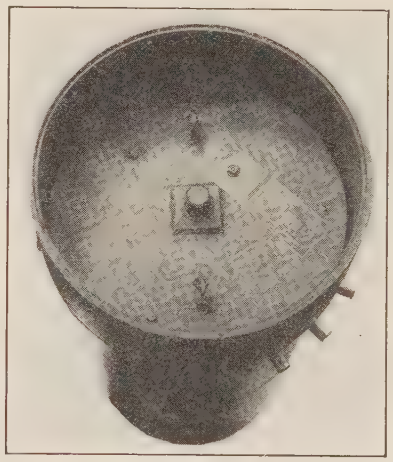

Fig. 7—Underground Distribution Transformers in Cast Iron Tank—Top View

lines, and supply a load having the characteristic shown in Fig. 4. Recording thermometers were installed, giving temperature of top oil in each transformer as well as the atmospheric temperature. Recording ampere meters were used on the high-voltage lead of each transformer to give the load record shown in Fig. 4. The core loss of each unit is 190 watts and copper loss at full load and 75 deg. cent. is 710 watts. Test results were kept for both units and these are

almost identical. Fig. 5 shows the result for one of the units.

It will be seen that for the same daily loading, the temperature of the oil follows the mean air temperature. Due to the smaller load carried by the transformer the temperature in the summer months falls off. The daily maximum load as well as daily average load is also indicated.

The highest temperature reached was 63 deg. cent. This occurred Feb. 1, 1928 when an average load for the day reached 80 per cent of transformer rating. The maximum load carried was 75 kv-a. Fig. 4 is for Feb. 1, 1928.

Construction and Operating Data

The case of the buried transformer (see Figs. 6 and 7) is made of cast iron and is provided with tinned wiping

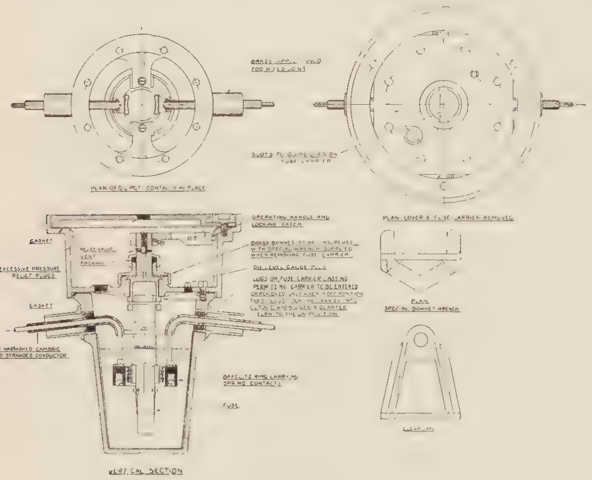

Fig. 8

sleeves for attachment of lead-covered paper-insulated cable leads to both high-voltage and low-voltage sides of the transformer. To make the tank hermetically tight, the cover of the transformer is bolted securely against a cork gasket. A cast iron housing 10 in. high is attached to the top of the case to support a checkered steel plate cover which is at ground level. This plate is loosely fitted and allows the entrance of surface moisture. Water entering the upper cover falls on the transformer cover proper and drips off its edge through drain pockets between the transformer case and the housing which supports the upper cover, thus reaching the earth surrounding the tank. The transformer cover is provided with a threaded hole for insertion of a thermometer or other temperature indicator. Another threaded hole normally closed with a pipe plug is provided at the proper point to allow the insertion of a small fiber tube to reach the bottom of the transformer case for securing bottom oil samples for test. Another threaded hole closed with a pipe plug is also located in the cover for the insertion of a key to operate the voltage ratio adjusting switch which is of the quick break type operating 2 in. below the oil level. This may be operated under load. The transformer is provided with three 4½ per cent reduced capacity taps in the 2400-volt winding. Thus when the tank is once properly sealed, it is not necessary to remove the cover to make temperature tests and oil inspections or to operate the tap changing switch.

It has been found that the entrance of moisture into the transformer case by so-called "breathing action" of the transformer, due to changes in temperature is prevented if a seal of the transformer is secured which will withstand a pressure in the tank of 10 lb. per sq. in. The test for this is made by means of a small portable air compressor, the air being led into the transformer case through a valve of the automobile tire type fitted into a pipe plug replacing the pipe plug covering the oil sampling hole in the cover.

Buried transformers, connected to supply lines on poles adjacent, are controlled on the high-voltage side by means of oil immersed fuse cut-outs of the outdoor type. These cut-outs also act as disconnecting switches and may be operated under full load. Where the high-voltage supply lines are also buried underground, however, it is not possible to use such a cut-out, as there is no vault or place to support it. A special buried type, oil immersed fuse cut-out has been developed for such applications, (see Fig. 8). This cut-out is installed similarly to the buried type of transformer and consists of a cast iron case having tinned outlets for attachment to lead-covered cable leads. It is provided with a checkered plate cover located at ground level, on the removal of which a switch handle is exposed. The moving of this handle operates the cut-out as a switch. It may be so operated under load. The cut-out is provided with a valve in the upper part of the fuse holder operating against a spring to allow the escape of any gases generated in the cut-out when the fuse blows; when pressure is relieved, the valve closes again thus preventing the entrance of moisture into the cut-out. A special box wrench is used to remove the fuse holder for replacing or examining the fuse.

The changing of a transformer on failure is accomplished by removing the cover, disconnecting the transformer leads from the lead-covered cable terminals inside the case, and withdrawing the transformer core. A new core is installed in place of the one removed, and connected to the cable terminals. The oil, if defective, may be changed by the use of ordinary oil pumps. The transformer case as well as all the lead covered cable connections to it is not disturbed in this operation. When the new core is in place, the same precautions for sealing the case are taken as on initial installation to make sure the case will withstand the desired air pressure.

At present, there are 30 buried transformers in operation in the city of Toronto. All are carrying commercial load in a similar manner to the test units described above. The conclusion may be that in a climate such as we have in Toronto, buried transformers will operate at nearly their normal full-load rating without exceeding the maximum operating temperature for which they were designed.

Auxiliaries for High-Voltage D-C. Multiple Unit Cars

BY C. J. AXTELL[1]
Associate, A. I. E. E.

Synopsis.—*The selection and application of auxiliary electrical devices on a high-voltage multiple unit car is of almost as much importance as the application of the main traction apparatus and requires careful consideration.*

This paper contains a description of the engineering features as worked out for electrified suburban lines operating on 1500-volt and 3000-volt systems.

The control circuits have become very generally standardized at 32-volts, which is also well adapted for interior illumination and headlights. A motor driven generator supplies 3- to 5-kw. power per unit for control lights and battery charging. Such devices as heaters and motor-generator sets, requiring a considerable amount of electrical power, are necessarily constructed to operate at trolley potential. On the 1500-volt system, the compressor can be operated directly from the line potential while on the 3000-volt systems, a double commutator motor driving the generator supplies a 1500-volt source of power for the compressor.

* * * * *

ON any electric car used in a service where multiple unit operation is required, there is a number of electric devices other than those required to actually control the propulsion of the car. Among the more important are the air compressors, heaters, lights, headlights, electric control of air brakes, automatic couplers, whistles or horns, signals, etc. Some of these devices require several kilowatts of power; others but a few watts.

For the control of reasonably large amounts of power,

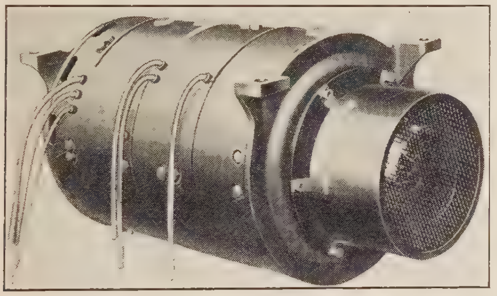

FIG. 1—3000-VOLT DYNAMOTOR GENERATOR

equipment can be economically made to handle power from either 1500-volt or 3000-volt sources. There are, however, many of the smaller devices where such a high potential would necessitate the use of insulating materials entirely out of proportion to the size and importance of the device. Consequently the use of a low-voltage current supply has been very generally adopted for these secondary circuits. Another reason, by no means an unimportant one, is the necessity for having a low-voltage source of power for the headlights, where high-speed operation in suburban zones is required. One of the requirements of a good headlight is that the filament be concentrated as nearly as possible to the focus of a parabolic mirror. This requires a short, thick filament operating at a low voltage. Since it projects an intense light down the track and also produces sufficient diffusion at the side to illuminate the right of way, a 32-volt lamp gives almost ideal headlighting. Fortunately the 32-volt source of power is also ideal for the control and auxiliary circuits. Furthermore, since cars for this class of service must have an auxiliary battery for lighting in case of the failure of power from the distributing system, a 32-volt secondary potential can be most advantageously used.

The only auxiliary device taking any appreciable amount of power, (except the heaters, which can be operated directly from the trolley source of potential), is the air compressor. On any system up to and including that with a 1500-volt trolley, the compressor

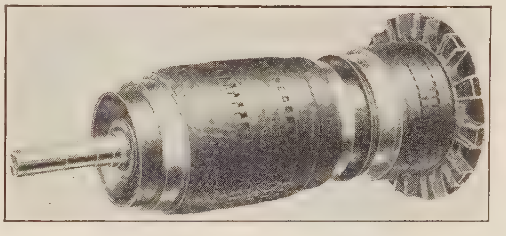

FIG. 2—ARMATURE OF 3000-VOLT DYNAMIC GENERATOR

will operate directly from the line potential. At the higher potentials, such as 3000 volts, the use of a dynamotor generator set fulfills the requirements. The dynamotor of this set has a dual function; the first, to furnish a source of power of one-half the line voltage for the operation of the air compressor, the second, to drive a small generator to supply current for the control, lights, headlight and other auxiliary circuits and also to maintain the auxiliary battery in a charged state. Since the dynamotor speed will vary with the line potential, it is necessary to provide a voltage regulator for the generator. The generator potential to be held will be governed by the lamps used and the number of cells and type of battery. With such a set, the battery can be floated continuously across the generator and kept in a fully charged condition.

1. Transportation Engg. Dept., General Electric Company, Erie, Pa.

Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Canada, June 23-27, 1930. Printed complete herein.

A description of the auxiliaries of two of the modern electrified steam railroad systems using high-voltage direct current, and operating multiple unit cars, may be of interest.

The Illinois Central Railroad suburban electrification in Chicago has a system potential of 1500 volts. This service is operated with 150 units, each consisting of a motor car and a trail car semi-permanently coupled. The length of the two-car unit is 145 ft. 5 in.; the weight, approximately 114 ton.

The Delaware, Lackawana and Western Railroad suburban line, at Hoboken, N. J., is being electrified for operation at 3000 volts. There will be 141 units, each consisting of a motor car and trailer. The size of the cars is practically the same as those used by the Illinois Central Railroad.

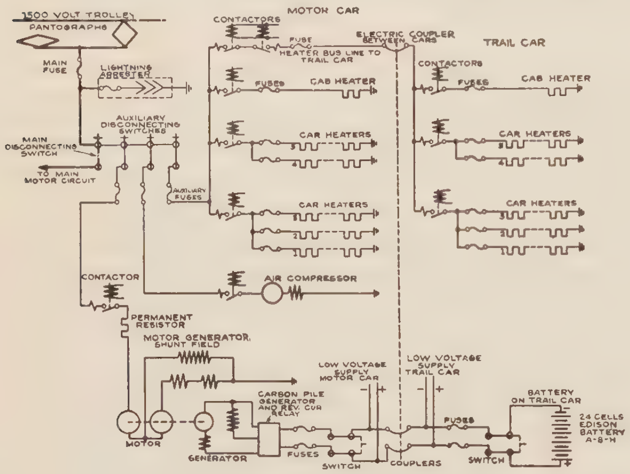

FIG. 3—TYPICAL CONNECTION DIAGRAM OF HIGH-VOLTAGE CIRCUITS FOR 1500-VOLT MULTIPLE UNIT CARS

The auxiliary devices and the source of power for supplying them are as follows:

Apparatus	Source of power
Electric heaters	Directly from trolley
Motor-generator (1500 volts)	" " "
Dynamotor generator (3000 volts)	" " "
Air compressor (1500-volt system)	" " "
(3000-volt system)	From mid-point of dynamotor
Lights, headlights, control current for motor controller, pantograph, heaters, compressor, doors, whistle or horn, signal, etc	From generator or battery

HEATERS

Electric heaters are now manufactured for operating directly from 1500-volt or 3000-volt sources of power and are arranged for underseat mounting. The heaters are of the same general outward appearance as have long been used on 600-volt systems. The heater element, however, is of greatly improved type. It is constructed as a helical coil imbedded in highly refractory insulating material in a steel tube. Thus the actual resistance wire is the completely protected. The regulations of the National Board of Fire Underwriters require that the temperature of the heater casing be limited to a relatively low value, which results in the operation of the heater elements at a much lower rating than is used in other classes of service. A high factor of safety exists therefore between the unit rating as applied to the heater and the actual point at which the heater element would fail.

On the multiple unit suburban cars of the Delaware, Lacakwanna and Western electrification, the heaters operating from the 3000-volt trolley are placed under the seats. The main heaters consist of two 14-kw. circuits per car. Each circuit has forty 75-volt 350-watt elements in series. The heaters are distributed so that one unit in each circuit is mounted in a heater casing under each seat. On these 3000-volt heaters, there are two insulations in series between the resistor wire and the sheet steel casing. The wire imbedded in its steel sheath is tested at a potential of 3500 volts a-c. for one minute. The sheath of the unit is insulated from the steel casing with porcelain insulators. The complete heater receives a high-potential test of 10,000 volts, alternating current, for one minute from resistance element to casing.

The heater units are so mounted in the steel casing that all terminals and live parts are completely protected and the ventilating louvers arranged to prevent any possibility of inserting an umbrella rod, wire, or any conductor into the case, so that it could make a contact with the heater sheath or any live part. The heater casings are individually grounded to a No. 6 A. w. g. ground cable, running the length of the car on each side and connected at both ends to the car underframe. These individual heater circuits are protected by 8-ampere fuses of the expulsion type.

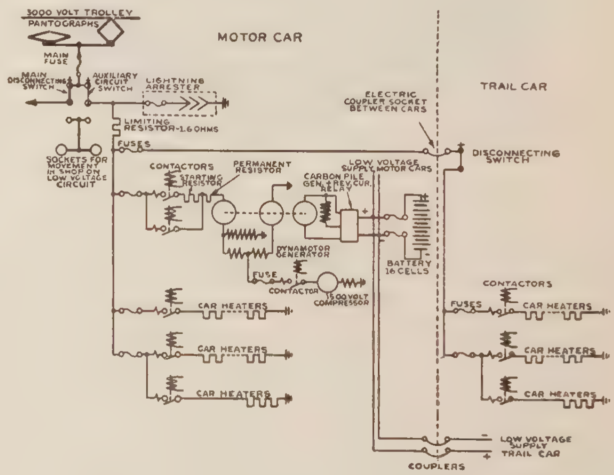

FIG. 4—TYPICAL CONNECTION DIAGRAM OF HIGH-VOLTAGE CIRCUITS FOR 3000-VOLT MULTIPLE UNIT CARS

The heat in the car is thermostatically controlled to maintain a constant temperature; 3000-volt magnetically operated contactors open and close the circuits for the heaters. These contactors are mounted in a

box underneath the car together with contactors for other auxiliary circuits. This type of contactor is used to permit switching on the heat, to warm up the cars previous to putting them in service, without having to maintain air pressure for operating electropneumatic contactors.

In each operating vestibule are three heaters of two, three, and five elements each. These heater

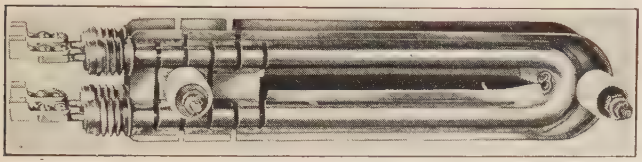

Fig. 5—3000-Volt Car Heater Units

elements are rated 340 watts each, thus providing a total heater capacity of 3400 watts for the vestibule. The cab heater is controlled independent of the car heaters. A push-button switch is provided in the cab to switch the heaters on and off. This switch is also arranged so that it will be opened and shut off power to the heaters if the compartment door is closed, as is the case on all but the operating cab. Trail car heater equipment is a duplicate of the motor car, power being taken to the trail car through a 3000-volt auxiliary bus line located on the roof of the car.

During the development of these electric heaters, tests were made to determine what disturbance, if any, would occur if some heater element or cable near the trolley side of the circuit should become grounded. On a test in which a ground connection was deliberately made to leave only one element in the circuit, the protecting fuse blew, and it was found that the heater element had also open-circuited, but was not grounded

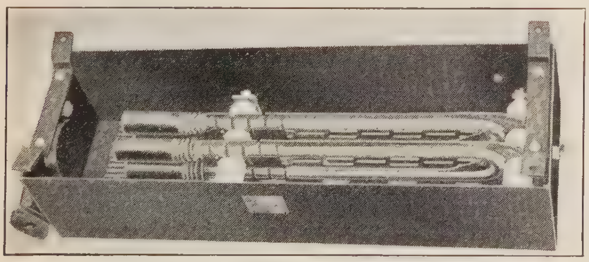

Fig. 6—3000-Volt Car Heater

to its enclosing sheath. No noise or flash was perceptible in the heater case. Tests were also made with a greater number of heater elements in the circuit, under which condition, the fuse protected the circuit completely and the heater elements were not damaged. If the heater element fails, it simply opens up the circuit as does a fuse, but without grounding to the sheath or causing any disturbance. To determine whether or not, after this abuse, the resistor unit was open-circuited, it was necessary to test the unit. The above 3000-volt heaters were manufactured after the same general design as those which had been in service on the 1500-volt electrification of the Illinois Central Railroad, the principal differences being in the increased insulation used on the higher voltage heaters.

The control of the 1500-volt and the 3000-volt heaters is practically the same; the 1500-volt current supply for the heater on the trail car on the Illinois Central Railroad cars is carried through a special 1500-volt contact in the automatic electric car coupler. Provision is made, if the cars should pull apart, to open

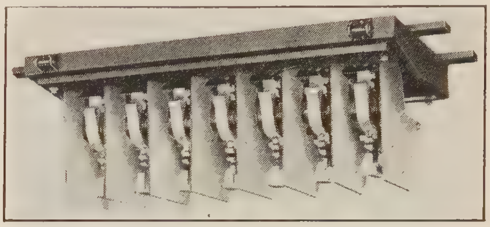

Fig. 7—1500-Volt Auxiliary Contactor Group

the control circuit of the two heater bus-line contactors. A control switch is also provided on the lever interlocking the coupler to open the control circuit of these contactors previous to the electric couplers being parted.

Motor-Generator and Dynamotor Generator Sets

To supply the various devices with low-voltage source of power, a motor operating from the line potential driving a generator of sufficient capacity for the low-voltage auxiliary circuits is used. On the 1500-volt

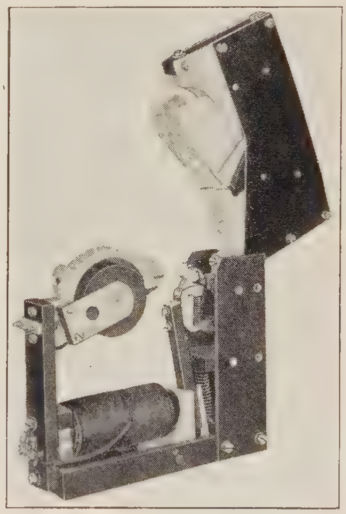

Fig. 8—3000-Volt Auxiliary Contactor

electrification of the Illinois Central, a motor-generator set of 3.5-kw. capacity was used. The set consists of a motor and a generator in a single frame. The motor is a compound-wound machine with sufficient series field to give good starting characteristics when connected directly to the line, and to produce a stable machine operating on a trolley of fluctuating potential. A permanent resistance of approximately six ohms is

used to cut down the first rush of current when starting, and permit the use of a smaller fuse to protect the motor, although it also acts to cut down any current surges which might result from rapid fluctuations of the trolley potential.

The motor is a double-commutator machine, each armature winding operating on 750 volts. The set is of two-bearing design with one ball bearing and one roller bearing, the latter to allow for the slight longitudinal movement necessary. A fan mounted between the generator and motor armature provides for ventilation. The generator is a compound-wound machine, having a rating of 3.5 kw. at 37 volts. For one unit, consisting of motor car and trailer it supplies all of the low-voltage power. The generator on the Illinois Central cars operates at a potential held constant by a carbon pile voltage regulator. The design of the set permits the generator to hold a constant voltage output on any trolley potential from a minimum of 1200 volts to a maximum of 1650 volts. The weight of the motor-generator set is 1300 lb.

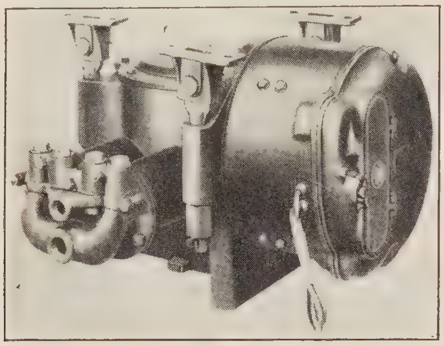

Fig. 9—1500-Volt Air Compressor

On the multiple unit cars of the Delaware, Lackawanna & Western 3000-volt electrification, a dynamotor generator set is used. In general mechanical construction, this is similar to the motor-generator set described. The motor in this set, however, has a dual function, in that it supplies as a dynamotor a potential of one-half trolley voltage for the operation of the 1500-volt air compressor. The output of the dynamotor is 7 kw. at 1500 volts. The control generator will deliver 4.5 kw. at 40 volts at any trolley potential from 2200 volts to 3500 volts. With the larger set and operating on 3000 volts line, an additional resistance of 48 ohms is connected in series for starting. The starting is entirely automatic, being so arranged that when the machine is connected to the line, both the permanent resistance (13.5 ohms) and the starting resistance (48 ohms) are in circuit. As the dynamotor approaches full speed, the generator voltage is built up; this energizes a magnetic contactor, which cuts out the starting resistance. On an interruption of line potential, when the motor slows down to approximately 40 per cent of the normal speed, the voltage of the generator will be sufficiently low to open this contactor and re-insert the starting resistance in the circuit. It was also found advisable to interlock the compressor starting contactor so that the compressor load would not be thrown on the dynamotor until it was practically up to speed. This dynamotor generator runs at a normal speed of 1250 rev. per min., and weighs approximately 2650 lb.

The dynamotor has four brush holders per commutator. The machine is of self-ventilated type, having a fan on the generator end which draws the air through the machine from the dynamotor end. A mechanical air cleaner, consisting of a fan so arranged as to throw out by centrifugal action any dirt that is in the cooling air, is mounted on the dynamotor end of the set.

The machine is supported on the car underframe through special rubber mountings so constructed that the resilience is obtained by having the rubber in tension instead of compression. Provision is made so that in the case of failure of the rubber, the support is taken up by the steel bolt.

Air Compressor

This is a standard type of single-stage motor-driven compressor, with a piston displacement of 36 cu. ft. per min., when operating at full load on the 1500-volt potential. A series motor running at 1060 rev. per min. drives the compressor, through a single reduction herring-bone gear, at a speed of 188 rev. per min. The two cylinders have diameters of $5\frac{1}{2}$ in., and a stroke of 7 in. The full-load current approximates 4.4 amperes.

Storage Batteries

These may be of either the lead or nickel alkaline type. The capacity of the battery to be used will be established by the number of hours of lighting desired to be available in case of failure of the power supply. Normally, the battery will be floated across the constant voltage of the generator and will be used to supply power only when the car is in the inspection shop or when some of the small auxiliary circuits, such as the heater contactors, may be supplied from the battery to avoid the necessity of operating the motor-generator set. The conditions of operating the battery are

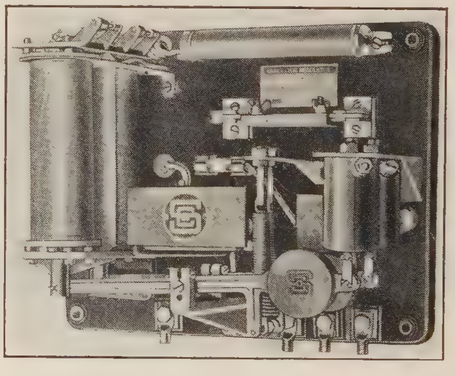

Fig. 10—Generator Voltage Regulator (Top View)

therefore radically different from those existing when the battery is used with an axle lighting generator, in which case the battery must carry all of the lighting load when the train is standing or running less than approximately 15 mi. per hr.

The Illinois Central Railroad cars carry 24 cells of Edison battery of 300-ampere-hour capacity mounted on the trail car. A lead battery of 16 cells of 300 ampere hour capacity will be used on the Delaware, Lackawanna & Western cars. These are mounted on the motor car.

Generator Voltage Regulator

The carbon pile type of regulator so long used by the steam railroads on axle lighting sets has worked out extremely well as a regulator for the multiple unit cars. As the generator runs continuously and the speed variation is relatively small compared with the axle lighting generator, the duty imposed on the regulator is much less than when used with axle lighting sets. This type of regulator will hold the generator voltage constant within plus or minus one volt.

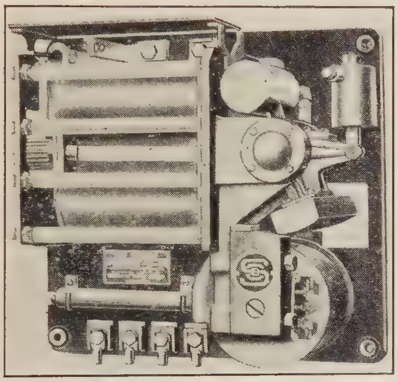

Fig. 11—Lamp Regulator

The reverse current relay has a combination of coils which connects the battery in the charging position when the generator potential exceeds the battery potential by one-half volt. With 25 cells of nickel alkaline battery, it will be necessary to run the generator potential between 37 and 40 volts, depending upon how much the battery is discharged in service, and also depending upon the temperature conditions. With 16 cells of lead battery the generator voltage will be set at some value between 34 and 36 volts.

Car Lighting, Headlighting, and Lighting Regulator

The car lighting and the headlights used can very well follow the practise which has become standardized on the particular railroad. It is advisable, however, to insure a high enough intensity of interior illumination to enable the passengers, usually commuters, to read with ease and comfort. Lights should be placed as high as possible and shaded to cut down the glare to a minimum. On electrified zones of steam lines, it has been customary to use headlights which would meet the Interstate Commerce Commission's ruling for locomotives. This requires that a man can be seen 800 ft. in front of the car on a dark night and necessitates the use of a lamp of 100 to 250 watts at 32 volts. The headlight also should have marker numbers on the side as is required for locomotive service. Provision is made to insert in series with the headlight lamp a small resistance when it is desired to dim the headlight, a switch short-circuiting this resistance being placed in convenient location for the motorman to reach.

With the nickel alkaline battery a lamp regulator is required to cut down the normal voltage at which the generator operates, to 32 volts at the lamps. With the 16 cells of lead battery, a lamp regulator will also probably be required as about 34 to 36 volts potential is required to charge the battery. With 15 cells of lead battery 32.5 to 34 volts will be the approximate potential required to charge the battery. In the latter case, if the lights were supplied directly from the battery as during a power interruption, the lamps will operate at slightly under their rated voltage. If automatic train signals are used, consideration must be given to the maximum variation of voltage recommended by the signal manufacturers which may necessitate the use of a 16-cell battery and a lamp regulator.

FAVORS SMALL FARMS

Predicting that 1,000,000 farms in the United States will receive electrical service within the next four years, a survey recently made by the Middle West Utilities Company attacks the theory that the farmer's problem would be greatly reduced if small farms were grouped into large ones.

"Because electric power is divisible and possesses the distinctive ability to reach small and scattered operations, users of small amounts of power can command as efficient a power supply as users of large quantities," it is stated. "In the application of electric power to agriculture this is greatly to the advantage of the family-unit size of farm.

"Because of the scattered jobs to be done and the kind of power available for and fitted to such jobs, the farm power plant of 50,000,000 hp., aggregate capacity, despite its enormous aggregate, still requires nearly two man-hours of labor for every hp-hr. of work delivered by its vast multitude of animals and machines. On our farms every year about 30,000,000,000 man-hours of work are required for every 16,000,000,000 hp-hr. delivered by animals and mechanisms. At the lowest estimate the work of women in the farmhouse totals another 15,000,000,000 'woman-hours.' "

It is concluded that the small farm stands to benefit particularly from the application of electricity to agriculture and that the family-unit farm is likely to persist instead of being replaced to any great extent by larger ones.—*Electrical World.*

Abridgment of

1000-Kw. Automatic Mercury Arc Rectifier Substation

of the Union Railway Company of New York

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and

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Synopsis.—*A 1000-kw. 625-volt automatic mercury arc rectifier substation, installed by the Union Railway Company of New York, in May, 1929, is described in general in this paper together with the account of the automatic and remote control features of the substations. The principle reasons for the adoption of the mercury arc rectifier are mentioned and operating and performance data for the first ten months' operation are presented.*

* * * * *

INTRODUCTION

IN May 1929, the Union Railway Company of New York put its first automatic rectifier substation in operation. This substation contains a 1000-kw. 625-volt rectifier set, supplied by 13,200-volt, three-phase, 60-cycle current. Its control is a combination of automatic load responsive and remote control. Provision is made for operation of the set on either 25- or 60-cycle.

The installation is noteworthy inasmuch as full benefit has been derived from the many advantages the mercury arc rectifier has over rotating converters. Such advantages are adaptability to automatic and remote control, operation on two frequencies, small weight and space, and absence of special foundations—all resulting in low installation costs.

DECIDING FACTORS IN THE CHOICE OF AUTOMATIC RECTIFIER

The 1000-kw. automatic rectifier substation in question supplies power to the street car system of the Westchester Square section, Bronx, N. Y. Previous to the installation of this rectifier, the d-c. power for this section was supplied from the Union Railway Company's substation at West Farms, located approximately three miles from Westchester Square. This substation contains 5000-kw. of 25-cycle synchronous converters.

Due to a steadily increasing load in the Westchester Square section, these converters, which are over 15 years old, could not handle the increased demand from this section much longer, so the railway company decided to install additional converting capacity. Estimates indicated that at least 1000 kw. of additional capacity was needed for present and future power requirements in this section. In order to reduce feeder losses to a minimum, it was decided to place the new converting equipment in the Bronx Gas & Electric Company's transformer substation at St. Peters and Westchester Ave. This substation is located right in the center of the Westchester Square section, where additional power was required. This new unit was to be equipped with fully automatic control, and provided for remote operation and indication from the railway company's station at West Farms.

For this new substation, both rotary converters and mercury arc rectifiers were considered, but after a careful investigation, the choice fell in favor of the rectifier.

While all the converting equipment of the Union Railway Company is of the 25-cycle type, 60-cycle converting apparatus had to be provided for this new substation as only 60-cycle power was then available. But inasmuch as it was questionable whether 25- or 60-cycle equipment would be used to greater advantage at some future time, it was highly desirable to provide the new converting equipment for operation on 25- and 60-cycle. Here again since it is not affected by the frequency of the supply system the mercury arc rectifier proved to be the ideal apparatus. It, of course, had to be designed for operation on both frequencies.

For the remote control from West Farms substation, only eight control wires were required. From Fig. 1, showing the substation layout, it can readily be seen that the rectifier apparatus fully utilize the available space, yet sufficient clearance exists between the apparatus for inspection.

DESCRIPTION OF THE EQUIPMENT

The 1000-kw. automatic rectifier plant consists of one 1000-kw. 625-volt nominally-rated rectifier unit, capable of carrying 50 per cent overload for two hours and 100 per cent overload for one minute. Energy is taken either from the 13,200-volt, three-phase 60-cycle main station bus or from the station auxiliary bus and converted to 625 volts, d-c.

Since mercury arc rectifiers and their standard auxiliary apparatus of similar types have been described in the JOURNAL of the A. I. E. E. before, these apparatus will be mentioned only in the following general manner.

The rectifier cylinder is of the 12-anode type and is cooled by fresh water. The anodes are water cooled. Fig. 2 shows the rectifier cylinder. As the rectifier

1. Both of American Brown Boveri Co., Inc.

Presented at the Summer Convention of the A. I. E. E., Toronto, Ontario, Canada, June 23-27, 1930. Complete copy upon request.

tank, when in operation, is under d-c. potential, it has been surrounded by a protective screen.

The rectifier receives energy from an oil insulated, self-cooled tubular type, outdoor transformer, with star-connected primary and double six-phase star-connected secondary winding. The primary winding is provided with one plus and one minus 3½ per cent full-capacity tap per phase and ratio adjuster for no-load operation. Due to space limitation, the interphase transformer which usually is built into a separate tank, has, in this case, been built directly into the rectifier transformer. The transformer is designed for operation on 25 or 60 cycles and 13,200 volts, three-phase current. The transformer impedance at 60 cycles is 4.5 per cent. When operated on 25 cycles, an external reactance of approximately 3 per cent has to be provided for protection of the transformer.

The pumping equipment for exhausting the air from

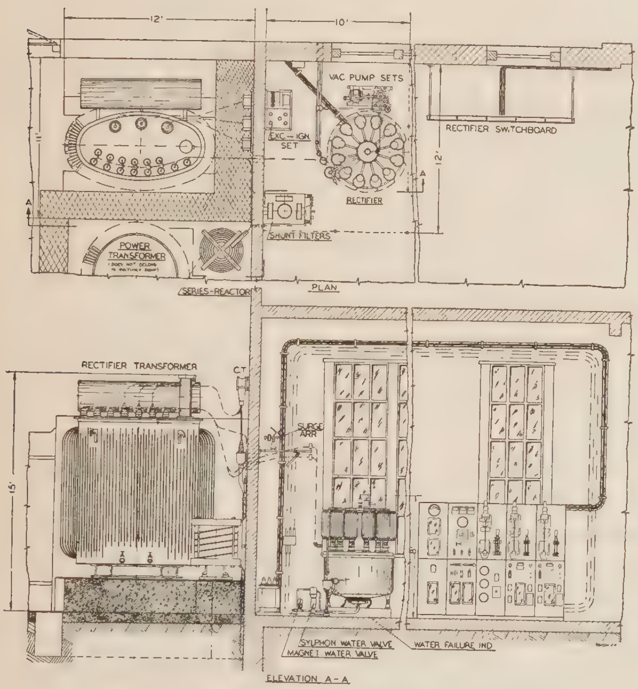

Fig. 1—1000-Kw. Automatic Rectifier

the rectifier cylinder consists of a water-cooled mercury vapor pump connected in series with a motor-driven rotary oil pump, all mounted on a common frame.

The ignition and excitation apparatus are mounted on a common angle iron frame and are provided for operation from a single-phase, low-voltage auxiliary supply.

The vacuum measuring device, as well as all the automatic control apparatus are operated from the same a-c. supply.

On the d-c. end the rectifier is connected to the bus through a single-pole, 3000-ampere solenoid-operated breaker with overload and reverse current trip.

Two 2000-ampere automatic reclosing feeder breakers connect the rectifier bus with the load.

The rectifier switchboard consists of five 24-in. by 90-in. slate panels. Fig. 3 shows the rectifier switchboard. Starting from the left-hand side, the first panel contains the automatic starting and stopping relays. The second panel contains the rectifier load and vacuum indicating instruments, drop annunciator, receptacles for various methods of control, control apparatus for breakers, and rectifier auxiliaries. The third panel

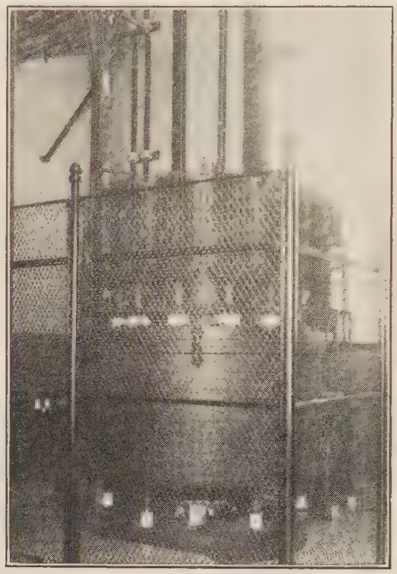

Fig. 2—1000-Kw. 625-Volt Mercury Arc Rectifier

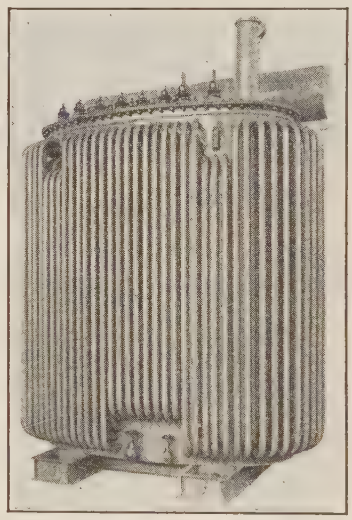

Fig. 3—1000-Kw. 13,200-Volt, Three-Phase, 2 x 6 Phase 25/60-Cycle Rectifier Transformer

contains the rectifier d-c. breaker, knife switch, induction type overload and breaker control relays. The fifth and sixth panel contain each a d-c. feeder breaker with knife switch, ammeter and feeder control relays.

For overvoltage protection, each secondary phase of the rectifier transformer is connected to a damping resistance and a horn gap arrester. The ground side of each arrester is connected to the common neutral of the transformer.

The rectifier set is provided with a filter equipment designed for the purpose of suppressing the ripple in the d-c. output of the rectifier to a point where it will not cause objectionable interference with telephone circuits. The equipment consists of a series reactor connected in the negative lead of the rectifier and three shunt filters, tuned for 360, 720, and 1080 cycles, which are the most disturbing frequencies for communication circuits. The series reactor is located outdoors, while the shunt filter with necessary fuses and knife switches mounted on a pipe frame, are located indoors within the enclosing screen of the rectifier.

Fig. 4 shows the single-line diagram of the rectifier plant.

I. Control of Auxiliaries.

The auxiliaries of a mercury arc rectifier consist of the excitation-ignition set, the cooling equipment and the vacuum pump set. The excitation-ignition set is energized by the closing of the a-c. breaker and maintains the excitation arcs as long as the a-c. breaker is

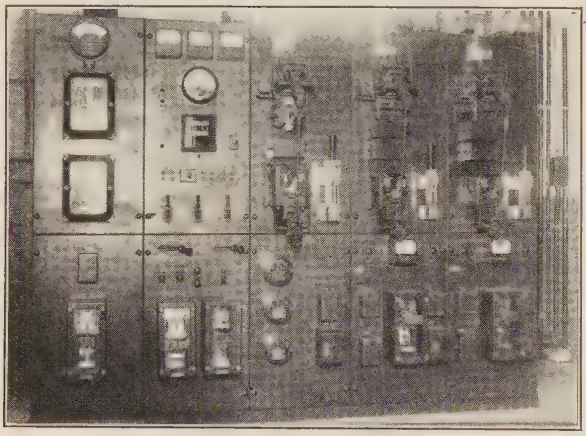

Fig. 4—Rectifier Switchboard of 1000-Kw. Automatic Substation

closed. In the same way, the magnet water valve controlling the rectifier cooling water is opened by the closing of the a-c. breaker.

Vacuum Pump Control. Unlike the excitation-ignition set and cooling apparatus, the vacuum pump operates independent of the rest of the plant, but so as required to maintain the vacuum in the rectifier. The contact-making vacuum meter is the nucleus of the vacuum pump control. Associated with it is the vacuum pump control relay, which also takes care of several protective functions necessitated by the nature of the vacuum pump set.

The gases are pumped from the rectifier in two stages by a mercury vapor pump and a rotary vacuum pump. A reservoir and an automatic valve are placed between the two stages so that continuous operation of the rotary pump is unnecessary. On the other hand, the high-vacuum pump must operate continuously.

II. Control of the Rectifier.

The control of the rectifier means the actual starting and stopping of the rectifier. In starting, the oil circuit breaker is closed first, energizing simultaneously the ignition-excitation apparatus and the rectifier cooling water valve. The d-c. breaker closes last, whereupon the rectifier immediately takes its share of the load. The starting generally requires from one to two seconds. In stopping, the oil circuit breaker opens first, tripping the d-c. breaker and stopping the excitation and the water at the same time.

A-c. Closing and Reclosing. The oil circuit breaker is controlled by the a-c. closing and reclosing relay, which makes three attempts to close the breaker, either on initial starting or after opening on overload. The third unsuccessful attempt to close automatically locks out the oil circuit breaker.

Protection. The rectifier is protected against sudden or continuous overloads, reverse current due to backfire, operation with poor vacuum, excessive temperature and cooling water failure.

When a back-fire occurs while the rectifier is paralleled with other machines, the reverse current trips the d-c. breaker, which in turn opens the oil circuit breaker through a special high-speed interlock. The interlock and tripping do not depend on auxiliary or control bus voltage and therefore attain the highest dependability.

III. Plant Control.

The plant control includes all devices and circuits which are used to stop and start the plant. The plant control in this substation consists of load responsive and remote controls. Instead of, or in addition to, the load responsive control, a time switch may be provided.

Where there are two or more units in a station, one unit is generally controlled by the master elements (*i. e.*, load responsive control, remote control, and clock or manual control), while the others are switched in or out according to the load on the first unit. These units are then designated as leading and lagging units, respectively. The signals from the master elements are automatically transferred to a lagging or reserve unit should the leading unit be locked out. This method is known as the "Transfer-Lockout" control.

Remote Control. In this installation, the plant can be controlled by the supervisor at West Farms Substation. He has continuous indication of the positions of all breakers and can, at will, assume control or relinquish it to the master controls in the station, without the necessity of having someone change the position of the selector switch.

IV. A-C. Feeders.

The station is supplied by two a-c. feeders which may furnish the power singly or jointly. For simplicity of control, and to avoid the use of an additional breaker for the rectifier, an electrically operated change-over switch is so connected to the auxiliary contacts of the two feeder breakers that it is in a position corresponding to "breaker closed" when either breaker or both breakers are closed, and in a position corresponding to

"breakers open" only when both breakers are open. For control purposes, therefore, this change-over switch may be regarded as a "phantom" rectifier a-c. breaker, the position of which indicates whether the power is on or off the rectifier.

If desirable, the a-c. feeders can be arranged for "preferred feeder" control. The change-over from the preferred to the emergency feeder is done automatically in this case, and when the trouble is cleared, the supply of power is transferred back to the preferred feeder. Either feeder can be made preferred by means of a selector switch. This type of preferred feeder control is also applied when power is supplied at 60 cycles over one feeder and at 25 cycles over the other feeder. In this case a series reactor is installed in circuit with the 25-cycle feeder for transformer protection and for maintaining the same regulation of the rectifier d-c. voltage as at 60 cycles.

V. *Automatic Reclosing D-C. Feeders.*

There are two automatic reclosing d-c. feeders in this substation. The feeder breakers are normally closed. When tripped by overload, the d-c. feeder reclosing relays will attempt to reclose them a predetermined number of times at predetermined time intervals. After the scheduled number of attempts have failed to close a breaker, it is locked out.

Remote Control. Since the remote control plays such a prominent part in this substation it is thought advisable to devote a few words to the system employed.

The remote control station is at West Farms Substation, about three miles away. The connections between the two stations are made over a telephone cable.

The breakers controlled are the a-c. feeder breakers and the two d-c. feeder breakers. Indication is provided for the "phantom" a-c. rectifier breaker, the d-c. rectifier breaker and the two d-c. feeder breakers.

In connection with the remote control, mention might be made of an inexpensive scheme of remote metering devised and installed by the railway company. The scheme utilizes the d-c. voltage drop across the series reactor of the telephone interference equipment to give an indication of the rectifier load at West Farms. A millivoltmeter at West Farms, calibrated with the line drop, indicates the load on the rectifier in amperes. The voltage drop across the reactor consists of a d-c. component and several a-c. components. To reduce reduce the a-c. component in the current through the millivoltmeter, a small reactor was installed in the leads.

Operation and Performance Data

The rectifier unit has been in successful operation since May 1929. The set is in service daily from 6:00 a. m. to 10:00 p. m.

Up to March 1, 1930, a total a-c. input of 2,334,800 kw-hr. had been metered on the rectifier. From this input figure it follows that the average monthly power consumption was 233,000 kw-hr. which corresponds to a daily load factor of from 45 to 50 per cent.

Measurements of the cooling water consumption of the rectifier and vacuum pump are available only up to October 10, 1929, and indicate that up to that date, 77,500 cu. ft. of water had been consumed, corresponding to 0.068 cubic feet per kw-hr. rectifier input.

The rectifier set is operating in parallel, through trolley wire and feeders with rotary converters of the neighboring substations. The rectifier is taking the proper share of the system load and no difficulty whatsoever has been experienced in parallel operation.

The filter equipment installed for suppressing the a-c. ripple in the rectifier output has been working satisfactorily, and no complaint of telephone interinterference has been received.

Conclusion

In the foregoing article a 1000-kw. automatic mercury arc rectifier installation has been described, with particular reference to its automatic control. The installation is a practical example to show that a rectifier can, without too many complications, be provided for automatic and remote control, that it can be installed in a very limited space without any changes to existing building and floor. Furthermore, the rectifier can be provided for operation on 25 and 60 cycles, where power at both frequencies is available, or may be considered in the future.

WIDE FIELD FOR ELECTRON TUBES

In an address before the Institute of Radio Engineers, O. H. Caldwell, editor of *Electronics* and of *Radio Retailing*, spoke of the electron tube, its development in the radio industry, and its present and potential application in non-radio fields, predicting that within a few years "there will be nothing that the average man sees, hears, or buys, but will be produced, affected or controlled in some way by an electron tube."

The particular adaptability of the tube to safety measures was pointed out, the "protection of life at sea and in the air, radio beacons and compasses, marine calls for help . . . weather communications and flying instructions concerning weather conditions," and the desirability of using radio broadcasting stations, which already have been "pressed into service in times of local disasters, blizzards, storms, etc., to communicate when other means have failed," for "general safeguarding of the nation" was emphasized.

Industrial use of electron tubes as protective devices around hazardous machines includes a safety guard on a punch press and a device for the safeguarding of electric circuits to warn against high-tension voltage.

Mr. Caldwell believes that the possibilities for development in this direction are almost unlimited.

The Status of the Young Engineer

President's Address

BY HAROLD B. SMITH

A LIFETIME'S work has been primarily with students of electrical engineering, and close connection has been enjoyed with many of them, not only immediately, but frequently for many years after graduation from college. It is natural, therefore, that it is counted a high privilege to have been brought closely into touch with their problems and their aspirations.

In this address, an attempt will be made to present some of the factors which appear to carry great weight with these young engineers in the critical years of the establishment of foundations for their future careers. There is a particular stimulus to do this at this time, because the whole problem of the status of the engineer is undergoing critical survey and it is believed that many of the problems which confront the young engineer at the very beginning of his professional experience offer a key which will be helpful to unlock problems apparently arising later in life. Much of this applies equally to young engineers other than those in electrical engineering.

Because of the comparatively few years that we have known the profession of engineering, even in its older branches, military and civil, we find comparatively few young men in college who are sons or close connections of older engineers upon whom they can depend for friendly, personal advice and guidance. Particularly is this true in electrical engineering where, while we still have with us many of that first small generation of the pioneers and even the second generation was not numerically large, we have only recently come to a generation numerically large enough to be able to cope with the multitudinous contacts and influences needed and desired by the larger generations now developing. The percentage of young men now in college and affiliated by close ties with older men of the engineering profession is much smaller than is desirable. The medical profession has some very useful and valuable policies in this connection of far reaching importance for the younger men. The profession of electrical engineering, in general, has but recently appreciated the importance of these relationships, as is evidenced by increased Branch activity and particularly by increased Branch and Section interrelationships. While this is a great help toward the solution of this problem, it is by no means the whole of it.

The young engineer of several decades ago, upon graduation found an old established order such that it was not always advisable to present his college training, abilities, and aspirations too prominently. The older apprenticeship system had not wholly disappeared and the earlier English influences in this respect were still strong in this country. Many of our organizations were still feeling that they were showing much consideration when they paid their new men fresh from college as much as six to nine cents per hour their first year. This was because they could make immediate comparison with other organizations still charging the new man an apprenticeship fee the first year. The industry has itself, and without undue pressure, recognized the financial needs of the young engineer for his own development and, under wise leadership, from time to time, has advanced the rate of compensation so that the young engineer may now expect to receive a reasonable rate of compensation upon starting upon his professional work. Not only that, but very largely throughout the industry is there now a fairly well fixed range of expectation. At least there is a fairly well established minimum rate of compensation to which any well trained and dependable young man of good ability may look forward as a starting compensation upon graduation. There is, if not a definite agreement, a sufficiency of understanding that a young man who has made a good record, not necessarily among the first of his class scholastically, but on the whole a *good* record, through four years of engineering college training, may reasonably expect to receive $125.00 to $150.00 per month his first year out of college and, depending upon a variety of conditions, sometimes much more. Frequently it is not the job that pays the most money the first few months that is most advisable for the young man to accept for his first experience. There are compensating and counterbalancing factors of great variety to be considered, both by the employer and by the young engineer. It is not thought that too great a uniformity should be set up for this initial starting compensation, nor is it likely that there will be. The present general understanding serves its purpose very satisfactorily in providing a sufficient and reasonable recognition of a minimum starting rate after the completion with a good record in a four year engineering college course. It sufficiently informs the profession, the college, the industry, and the individual of reasonable limits upon which they can plan and build for the future. This is true, even if it be recognized at the beginning that modification may be brought about from time to time as changing conditions may justify.

The above is all predicated upon the thought which has been expressed in the findings of the reports of The Society for the Promotion of Engineering Education, The Carnegie Foundation for the Advancement of

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Teaching, and other bodies or committees, that the normal and advisable college course for the average engineering student is a four year course. The needs of engineering and industry are met in the majority of cases by recruiting, shall we say, three-quarters of the men necessary from those who have secured for themselves a good four year engineering training. The profession and the industry are most vitally conerned, however, with the recruiting of the remaining twenty-five per cent or less who are imperatively needed with a training beyond that which can be secured during a four year period. A training which, depending upon the field of engineeering activity proposed, may consist of any one of an almost endless variety of important combinations, almost any one of which, including actual applied practise, may either precede, or be interspersed with, the usual four year engineering college course or may wholly follow such a course. In general, where they follow after such a course, they are designed for specialized study for definite purposes—mathematics, physics, business, manufacturing, design, production, or various other lines, or through experience in actual applied engineering work along some important line. These are the young men interested in securing the most thorough training for their life work, with whom the colleges, the profession, and the industry are especially concerned, and for whom they are highly responsible.

One of the great difficulties of this problem lies in the suitable selection of the twenty-five per cent, or even a ten per cent, of the students who are so constituted that they can profitably devote one, two, or three years to further training along purely analytic, theoretic, or applied lines, or some advisable combination of them. This selection is attempted in various ways at present by various agencies: Fellowships and scholarships of various sorts by the colleges; grants by various foundations for many purposes; plans for support of graduate study and research, etc., etc. There is not enough of this sort of endeavor and when more is attempted many complications arise. It has been suggested recently* that "perhaps not enough has been done by the cooperation of the several engineering societies standing back of the educational institutions and with the cooperation of the applied engineering industry as a whole." The thought lying back of this suggestion has resulted from personal talks with executives of organizations, particularly with those having to do with the building up of personnel, with recruiting representatives, and with officers of colleges and the professional societies.

Briefly, it is a suggestion that, after suitable study by a properly organized committee of an independent organization such as the American Engineering Council or the Engineering Foundation, with ample representation of engineering industry, and based upon such recommendation as they find advisable, an attempt be made by these several agencies to establish some sort of differential for general and substantial recognition, if not actual agreement, which will provide a sufficiently definite rate to be expected by the young engineer of suitable characteristics for an initial starting salary after one, two, or three years of effective graduate work. What such a differential should be must be a matter for much consideration, and possibly can be decided upon after actual trial. There is sufficient agreement, as matters now stand, so that it does not seem to be too much to hope for a result as tangible as now exists for the initial starting salary at the end of a four year course.

With no thought of final acceptance for such a purpose in the form proposed, but in order to illustrate the purpose of such a plan, let us set up a trial schedule to make such a suggestion a little more definite and to emphasize some of its advantages. Suppose it be assumed that the following schedule is effective as fairly representing effective minimum rates, which may reasonably be expected by the young engineer, it is believed that one of the principal advantages lies merely in the recognition of a more or less substantial understanding of such a schedule of minimum rates.

SCHEDULE

	Minimum initial starting salary for first year, at end of four year college training or equivalent	Total minimum
After satisfactory completion of a good four year engineering course or equivalent............say—	$1750.00	$1750.00 four years
In addition, and after a fifth year of effective graduate work, 5 years training..............say—	250.00	2000.00 five years
In addition, and after a sixth year of effective graduate work, 6 years training..............say—	250.00	2250.00 six years
In addition, and after a seventh year of effective graduate work, 7 years training..............say—	250.00	2500.00 seven years

It is found that with every group of students coming to graduation and being interviewed by representatives of the various engineering and industrial organizations, there are several points of view which must be taken into consideration. A not infrequent statement on the part of the interviewer is the interest of his organization in "a few of the best men" of the class. It is probably true that each of the interviewers visiting a given institution will not succeed in picking out and securing the services of all of the "best men." If some such schedule as that proposed is set up by the industry and recognized so far as found practicable, it is believed

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that students themselves will to a large extent pick themselves out for this ten to twenty per cent in which we are all of us so greatly interested. It is also believed that they will "pick themselves" with more accurate judgment on the whole than possible for any one else.

A certain percentage of each graduating class, even though they have profited greatly from their four year training and have good records back of them, have secured this result only at great effort, or, indeed, may have required five years in which to complete the four year training. They have discovered that there are certain types of effort for which they are not well adapted. No one needs to tell them whether to give themselves further advanced study in college or not. They know. And fortunately there is an immediate need and an active need for just this type of man directly following his four year training. Some of them could not be induced to submit themselves to further college training and they readily find the work for which they are well adapted and in which the records show they will prove highly successful.

Then there is a smaller percentage of men who enjoy the college work of analytic and theoretic, or more practical, laboratory or research type and realize themselves that they can profit by further training of this character. They resolve themselves into at least three classes: (a) Those who have financial resources to avail themselves of such training. We sometimes find such men indulging themselves unreasonably and unprofitably in this way. It is the comparatively few of this type who have brought criticism upon themselves and others. (b) Those without financial resources, but who find means to meet their needs through fellowships, scholarships, various funds, etc. (c) Those without financial resources to permit advanced training, but who, themselves, know better than any one else can possibly learn, instructor, recruiting representative or close friend, how definitely they would appreciate and profit from a suitable amount of the type of advanced training for which they are definitely fitted and which they usually definitely crave. It is for the benefit of these men who are of the type that yield us those who go far as the years progress that this proposed plan is presented for consideration. It is also for the benefit of the profession as a whole that it is hoped that some such plan can be established so that we have coming into the profession each year a small well trained group of most able young engineers who will promptly find their places in the inspiring leadership of the profession.

With a reasonably definite differential set up, and under some such sort of an understanding as has been described, these are the men who would, under such an understanding, pick themselves out and under such a plan would find an urge for this training which would enable them, with the differential in mind, to finance themselves. It is believed that the right men would pick themselves out for more advanced training with greater certainty and, on the whole, truer insight into their own qualifications than their instructors or most proficient recruiting representatives could possibly do. The instructor and his advice would not be eliminated. He would still be helpful. They would have to borrow the money for this training, which the differential would permit and would justify them in doing. It would, however, make it their own responsibility to do so and ultimately repay it. They would scrutinize their own inclinations, abilities, and the character of the work they took up with utmost consideration under such conditions. They would, better than any one else, know whether their capacities and urge would justify borrowing for one, two, or three years training. They would, with good advice and better than any one else, know when such training should be interspersed with applied work of a less theoretic character.

The responsibility for the best use of the time, effort, and money for more of advanced training for a comparatively small percentage of men would rest definitely upon those men who elect to secure such training. Industry, the profession, the colleges, by cooperating in setting up some such sufficiently understood and accepted schedule, merely provide a tangible basis upon which the young engineer may understandingly make his decision, at the time when such a decision is necessary for him. It is believed that engineering and industry are prepared to meet the expense involved in such a plan. In fact, such expense is virtually being met at the present time, and more men of the type such a plan would produce are needed. It would be a somewhat gradual development and probably subject to slow modification as time proceeds and as experience dictates. The careful study of such a plan and its possibilities and limitations is recommended.

The mercury-vapor generating unit at the South Meadow station of the Hartford Electric Light Company is producing a net kilowatt-hour upon a fuel consumption of seven-tenths of a pound, or approximately 10,000 B. t. u., in regular daily service, according to a recent announcement by President Samuel Ferguson. Comprehensive tests of this unit by Stone & Webster and the General Electric Company are now being analyzed and will be made public in the near future, together with an official statement by Vice-President T. H. Soren of the Hartford company as to the economy and reliability of the mercury-vapor process in commercial central-station service.

News of this achievement is spreading swiftly through power engineering circles; the record-breaking figure above cited is arousing even the more skeptical prime mover and plant designers to study the process seriously, and competition to take advantage of this development is already in sight. Every passing week since February 4th has furnished cumulative evidence that a tremendous forward step has been taken in the application of the process evolved by Mr. Emmet and his associates to heavy-duty power production.—*Electrical World.*

End-Connection Reactance of Synchronous Machines

BY ALFRED STILL*

Fellow, A. I. E. E.

MUCH has been published lately on the subject of armature reaction, and the designer is now able to predetermine performances with a considerable degree of accuracy; but many of the assumptions made for the purpose of obtaining a mathematical solution to a difficult problem have tended to obscure rather than elucidate the physical conception of armature reactance. This may be of no serious importance when dealing with standard types of design, but in the development of new ideas or in making calculations on abnormal designs, a clear conception of the magnetic flux linking with the armature windings and so causing a reactive voltage is necessary to the development of new formulas or the intelligent application of existing formulas.

The writer will confine himself to the development of a new formula for the reactance of the overhanging portions of the windings; that is to say, of the "end connections" wherein the currents establish a flux of self-induction which is independent of the flux entering the armature core from the poles. In this development, the armature conductors projecting beyond the ends of the slots will be considered as "cutting" the self-created magnetic field exactly as the "active" conductors may be considered as cutting the flux lines entering the core through the air-gap.

In order to simplify the problem and justify the use of sine functions for the m. m. f. distribution over armature periphery, it will be convenient to assume that there are as many phase windings as there are slots in the space of one pole pitch, and that the current distribution over the armature periphery is sinusoidal.

Regardless of the position relatively to the poles of the conductor carrying the maximum current, a field of flux will be created by the current in the end connections which will be approximately stationary in space if the armature revolves, and which will revolve at the same speed as the field poles if the armature is stationary. The space available per pole for this flux depends upon the product of the pole pitch τ and the distance l' where l' is the "overhang" or amount of projection of the armature coils beyond the ends of the slots. This space is the shaded area (*both* ends of the armature core) as indicated in Fig. 1. The induced e. m. f. or $(I\,X)_{ends}$ is simply the result of the "cutting" of this flux by the overhanging portion of the conductors, and if the flux linking the conductors in the space $2\,\tau\,l'$ can be calculated, the quantity $(I\,X)_{ends}$ can be determined exactly as the voltage developed in the "active" conductors can be determined when the amount of the "useful" flux per pole is known. If it were possible for the area $\tau\,l'$ to be zero, there would be no $I\,X$ drop in the end connections because there would be no space for self-induced flux outside of the iron core.

Calculation of End Flux. Assuming the air-gap diameter to be large, the "developed" view of the conductors on the armature periphery as shown in Fig. 2 is a fairly correct representation of the end connections of a nine-phase single-layer winding with nine slots per

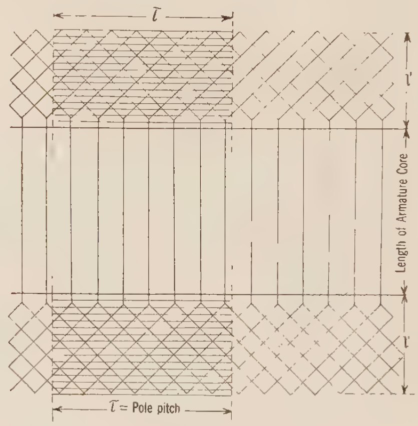

FIG. 1

pole, or one slot per pole per phase. The following symbols will be used:

- I_c = r. m. s. value of armature current
- n = number of phases
- n_s = number of slots per pole per phase
- C_s = number of conductors per slot (carrying the current I_c amperes)
- λ = slot pitch in cm.
- τ = pole pitch in cm. ($\tau = \lambda\,n\,n_s$)

With a coil span equal to the pole pitch τ, and a maximum current of $\sqrt{2}\,I_c$ amperes in the coil a, in the position marked O in Fig. 2, the current will fall off in successive conductor positions according to the sine law until, in the position M exactly 90 electrical degrees (or 4½ slots) distant from O, the current in the conductor will be zero. The m. m. f. tending to establish flux in any of the spaces between conductors can easily be calculated by computing the total ampere-turns surrounding the area considered. Thus the shaded areas of Fig. 2 are surrounded by the greatest number of ampere-turns, and the maximum m. m. f. per pole will be found to occur in the position M where the current is zero, the ampere-turns *per pole* being half the sum of the ampere-turns tending to set up

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flux in the two shaded areas of Fig. 2. If M stands for this maximum armature m. m. f. in gilberts, it can easily be shown that

$$M = 0.4 \sqrt{2}\, n\, n_s\, C_s\, I_c \text{ gilberts per pole} \qquad (1)$$

The sinusoidal distribution of this m. m. f. over the armature periphery is indicated by the curve M of Fig. 3, where the datum line $X'X$ represents the armature periphery, and the lines in the diagram must be

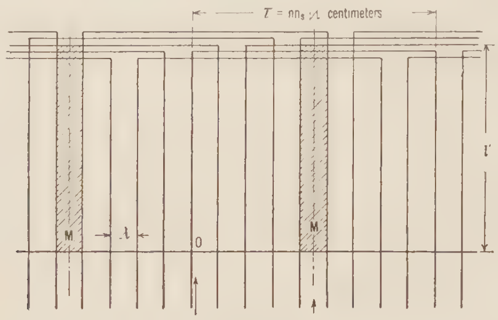

Fig. 2

considered as being in a plane perpendicular to the conductors shown in Fig. 2.

In order to obtain the curve B of flux distribution over the armature periphery in the space outside the slots, the flux paths will be assumed to be circles described from a center which is the point on the armature periphery where the current reaches its maximum value of $\sqrt{2}\, I_c$. Let α be the distance (expressed in electrical degrees) from the center O, of any point Q

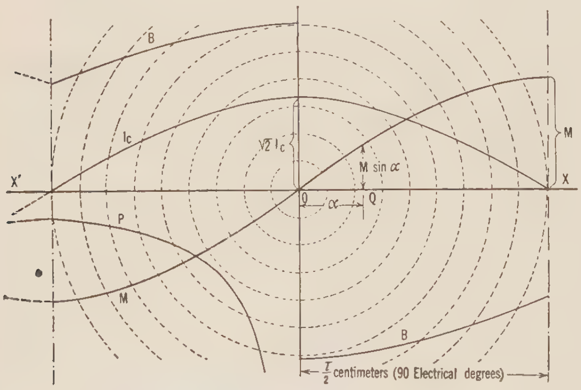

Fig. 3

on the armature periphery, then the magnetizing force at this point is

$$H = \frac{\text{m. m. f., in gilberts}}{\text{length of path in cm.}} = \frac{M \sin \alpha}{\pi \dfrac{\tau}{2} \left(\dfrac{\alpha}{90} \right)} \qquad (2)$$

This is also the value of the flux density B in maxwells per sq. cm., since for the present we are neglecting the effect of neighboring masses of iron. The quantity $\dfrac{180}{\alpha \pi \tau}$ may be thought of as the permeance of a semi-circular flux path of 1-cm. cross-section. This quantity is represented by the ordinates of the rectangular hyperbola marked P in Fig. 3, and the flux distribution curve B is the result of multiplying together corresponding ordinates of the curves M and B. Since we may write

$$B = \frac{M}{\pi \tau} \left(\frac{180 \sin \alpha}{\alpha} \right) \text{maxwells per sq. cm.} \qquad \textbf{(2a)}$$

it is seen that the average value of B over the pole pitch may be obtained by calculating the average value of $\dfrac{180 \sin \alpha}{\alpha}$ between the limits $\alpha = 90$ deg. and $\alpha = 0$ deg. This value is approximately 2.74. Putting this in formula (**2a**) and making other substitutions, we obtain (approximately),

$$B_{average} = 0.5\, k \frac{C_s\, I_c}{\lambda} \text{ maxwells per sq. cm.} \qquad (3)$$

The factor k has been introduced to take account of

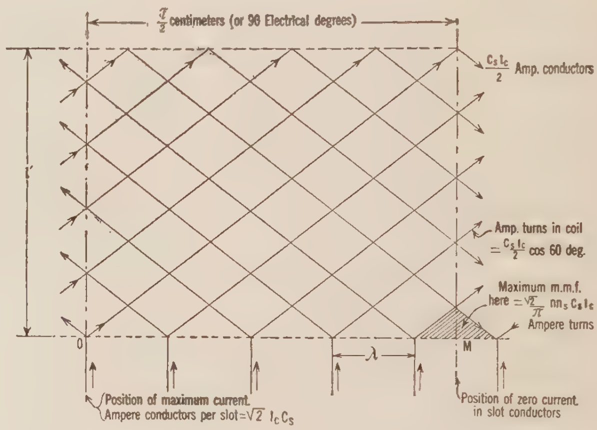

Fig. 4

the fact that masses of iron in the path of the flux lines will reduce the reluctance of the flux paths, and in any practical machine, the factor k will always be greater than unity. The total amount of self-induced end flux per pole which links with the overhanging portion of the windings is obtained when $B_{average}$ is multiplied by the area $2\, \tau\, l'$. The result *for single-layer windings* may be put in the form

$$\Phi_e = k\, n\, n_s\, C_s\, I_c\, l' \text{ maxwells} \qquad (4)$$

If Φ_p stands for the flux per pole which enters the armature core and is cut by the conductors in the slots, it follows that the e. m. f. induced in the end connections, expressed as a percentage of the developed e. m. f., is

$$\text{Percentage } (I\, X)_{ends} = 100 \frac{\Phi_e}{\Phi_p} \qquad (5)$$

Distribution of End Flux with Double-Layer Winding. With the more usual double-layer winding, the end connections will no longer be as shown in Fig. 2, but will appear as in Fig. 4. The m. m. f. tending to estab-

lish flux may be computed by noting the total resultant ampere-turns around any one of the diamond-shaped spaces formed by the crossing of the two layers of conductors. The thickness of these layers is neglected, and the two sets of conductors are assumed to lie in the same plane. The *maximum* m. m. f. per pole, which occurs in the space marked M, will be the same as for the single-layer winding; that is to say, it will still be equal to the maximum value of the armature m. m. f. per pole. Moreover, this m. m. f. will fall off according to the sine law until it becomes zero where

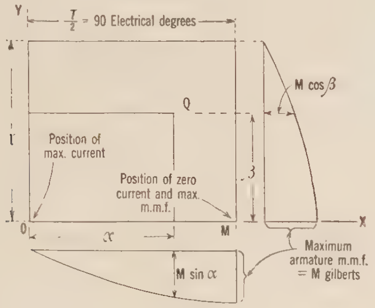

FIG. 5

the current in the slot conductors has its maximum value; but instead of being constant in value in the axial direction (as it is for the single-layer winding of Fig. 2), the m. m. f. will now be found to fall off, also in accordance with the sine law, until its value becomes zero at all points where the overhang has the limiting value l'. This is illustrated in Fig. 5, from which it is seen that the m. m. f. at any point Q is equal to $M \sin \alpha \cos \beta$, where M is the maximum m. m. f. as given by formula (**1**), α has the same meaning as in Fig. 3, and β is the axial distance from the end of the armature core expressed as an angle with the maximum overhang l' considered as 90 deg. Since the average value of $\cos \beta$ between $\beta = 90$ and $\beta = 0$ is $2/\pi$, it follows that $B_{average}$ and Φ_e and $(I\,X)_{ends}$, when a double-layer winding is used, will be $2/\pi$ times the values obtained for a single-layer winding. Thus for a double-layer winding the formula (4) becomes

$$\Phi_e = 0.635\, k\, n\, n_s\, C_s\, I_c\, l' \text{ maxwells} \qquad (\mathbf{4a})$$

When estimating l' for use in formula (**4a**), it is well to use a length somewhat greater than the straight overhang of the windings beyond the slot. In this manner, the necessary allowance can be made (1) for the flux linking with the bend at the end of the coils, and (2) for the fact that the flux density does not fall off immediately after the coils leave the slots. This is explained in Fig. 6, where a is the straight projection beyond the slot of the two coil sides before the upper and lower layers of the winding branch off in different directions. The equivalent overhang for use in formula (**4a**), expressed in terms of the dimensions in Fig. 5, is

$$l' = b + \frac{\pi}{2}\,(a + c) \text{ cm.} \qquad (5)$$

The multiplier k in formulas (3), (4) and (**4a**) depends upon the amount of iron in the path of the magnetic flux linking with the end connections. Since it cannot easily be calculated, it is really an empirical coefficient. The writer suggests for k the value $k = 1.7$ for slow-speed salient-pole generators, and $k = 3.5$ for high-speed turbo generators.

Reactance of End Connections. Using the formulas (4) or (**4a**) for the flux per pole which is "cut" by the end connections, the calculation of the induced voltage or $(I\,X)_{ends}$ is made exactly as when calculating the e. m. f. developed by the cutting of the flux which enters the armature through the air-gap. On the sine-wave assumption,* with a full-pitch winding, we may use the formula

$$(I\,X)_{ends} = \frac{\pi}{2} f\, \Phi_e\, (n_s\, C_s\, p)\, 10^{-8} \text{ volts} \qquad (\mathbf{6})$$

where f = frequency in cycles per second, p = number of poles, n_s = number of slots per pole per phase, and C_s = number of (series) conductors per slot. Before substituting the calculated value of Φ_e, another factor should be introduced to take account of the short-pitch windings which are common in modern designs. Let d stand for the winding factor which may take account of both coil pitch and width of phase belt. For example, with a coil pitch of two-thirds the pole pitch and a three-phase winding with four slots per pole per phase, the numerical value of this factor would be $d = 0.958 \sin (90 \times 2/3) = 0.83$, where the multiplier 0.958 is the distribution factor due to the phase-belt being spread over four slots per pole. If the armature end connections were cutting a sinusoidal flux provided by an independent winding, the developed voltage would be d times the voltage given by formula (**6**); but since the flux cut is produced by the armature winding itself, the flux Φ_e of formulas (4) and (**4a**) will have to be reduced to the same

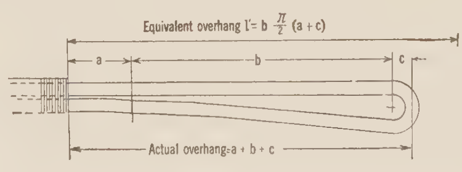

FIG. 6

extent, so that it is the quantity d^2 which must be introduced as a correcting factor in the final formula. With this addition, and after making the necessary substitution and omitting the current I_c, the final formula for end-connection reactance per phase winding for a polyphase synchronous machine with double-layer winding becomes

$$X_e = n \sqrt{2}\, k\, d^2 f\, (n_s\, C_s)^2\, p\, l' \times 10^{-8} \text{ ohms} \qquad (7)$$

where the number of phases n is three or more. For a

*This assumption is made to simplify the work. The flux distribution (curve B of Fig. 3) is not sinusoidal.

single-layer winding, the reactance as calculated by formula (7) must be multiplied by $\pi/2$.

It should be noted that the only dimension of length appearing in this formula is the overhang of l' cm. measured in the direction of the axis of rotation. In the earlier formulas used by designers, the reactance is assumed to be proportional to the total length of coil outside the slots. Later formulas use the span or pitch of the coil, and also the square root of the pitch, as the geometric dimension which determines the reactance. Since both the length of conductor outside the slots and the maximum projection beyond the slots are largely dependent upon the coil pitch, it is not surprizing that many of the various formulas in use, especially when applied to standard types of design, give reasonably good results in practise. However, in the hypothetical case of zero projection beyond the ends of the slots, there would obviously be no space for flux to link with the end connections, regardless of the coil span or the length of end connection measured from slot to slot along the armature periphery. There would be no flux set up by the end connections outside of the armature core, and the quantity X_e would be zero. The formula (7) with $l = 0$ is therefore applicable to this hypothetical case, but it is probable that formulas which assume the end reactance to be proportional to the length of end connections or to the coil span would give incorrect results if applied to special windings with abnormally small extension beyond the ends of the slots.

Abridgment of

Dancing Conductors

BY A. E. DAVISON*

Associate, A. I. E. E.

***Synopsis.**—The phenomenon of dancing cables is discussed; the merits of different theories are considered, reference being made to the theory that vibrations of small amplitude but relatively high frequency travel along the line to points where the constants of the line change, as at dead-ending insulators, and there reflect and combine into slower waves of great amplitude. The suggestion is made that much experimental work should be done with regard to these theories before drawing any definite conclusions.*

Reference is made to Magnus Effect and to the "lift" of ice-coated cables in wind storms. This lift, perpendicular to the direction of the wind, is carefully considered, and diagrams show experimental values of this lift on models similar to the ice-coated cables. The diagrams indicate variations and reversals of this thrust due to small changes of angle of the specimen to the direction of the wind. The suggestion is made that these alternate lifting and depressing effects should be considered as the cause of some, if not a large percentage, of the phenomenal movements of ice-coated conductors in relatively light winds.

As in most earlier reports and discussions there does not seem to be any remedy as a result of this study, other than the heating of the conductor electrically to such a temperature throughout sleet-forming periods that the sleet cannot form on the wires.

Review of Theoretical Considerations and Published Data

SEMENZA is credited with having first advanced a theory that the small movements (sometimes called the natural or fundamental vibrations of a line) are caused by longitudinal mechanical pulsations put into the line by changes in the mechanical tensions due to the swinging of the cables in light winds.

A span may be swinging at some relatively slow angular velocity during each cycle of which there are charges of tension in that particular span. The local tension is maximum near the lowest point of the swing and least, (reaching almost zero) when the motion reverses, especially if the arc of the swing should become greater than 180 deg. These alternate increments and decrements of tension send out into adjoining spans, pulses of varying frequencies depending upon such physical conditions as length of spans, wind velocities, and temperatures.

When several groups of these mechanical pulses are transmitted, the increments and decrements of tension are in some cases counteracted; in other cases, they combine to give rise to a resultant well-defined wave of tension. The question of how much damping occurs during this process of combination and eliminations to give the resultant natural frequency wave has not been studied but if, as some appear to believe, this tension wave can travel along the line without much loss of energy, then it may travel great distances. Semenza may not have carried the idea further; however, if the frequency of this wave be the natural frequency of one of the spans through which it passes, then it is conceivable that this span will respond to this high frequency and start oscillating, as a whole or with only one or two nodes, at much lower frequency.

Many other suggestions and theoretical considerations have been reviewed regarding causes and effects and all have merit. It is not intended that efforts should be abandoned to connect up the small rapid vibrations with boisterous galloping, which is almost sure to cause short circuits and grounds and even do mechanical damage to structures. Standing waves and

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Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Can., June 23-27, 1930. Complete copy upon request.

almost every sort of odd and exaggerated performance may be observed in 100 ft. or so of a light rope or line supported at intervals by vertical strings, comparable to suspension insulators, when very small mechanical impulses are put into the line at one end, and the other end is fixed. As the result of either longitudinal or transverse impulses these vibrations can be introduced quite effectually. The latter especially require very little effort. As a result of this review of data, it becomes evident that no theory has yet been found by which the accumulation of small vibrations into galloping can be substantiated by calculations and experiment. This may be done later however by the use of satisfying assumptions and through further experiments and supporting calculations. Further work along this line will doubtless be quite profitable and it is not intended that any suggestion or result recorded in this paper should in any way check further study and development of these ideas.

Comparative Study of Phenomenal Movements

Two instances of extraordinary movements of conductors were reported during the latter part of 1927, by E. G. Archer of the Hydro-Electric Power Commission,—one at Whitby and one at Niagara Falls. The case at Whitby showed violent swinging; the temperature was well above 60 deg. fahr. and there was a gale. Conditions were evidently quite similar to those which Haussadis[1] had in mind.

At Niagara Falls, with a wind of approximately 30 mi. per hour blowing nearly at right angles to the line, and accompanied by a fine sleet a condition was observed, so peculiar that it commanded attention. Two tower lines supported one circuit each, and a third tower line carried two circuits. All cables were supported by suspension insulators, and the tower lines paralleled one another closely. One circuit on a single-tower line and one of the circuits on the double-circuit line were dancing. The other circuit on the double-circuit line had been reported as dancing earlier in the day but had stopped. The dancing was localized to one span and the motions did not appear to be transmitted to the adjacent spans. The suspension insulators were not moved out of line, although the dancing appeared to carry the cables vertically, at center of 400- to 500-ft. spans, approximately 15 ft.

These two observations separated by only a few months were so different as to weather conditions and resulting phenomena that the observer suggested some explanation of the extraordinary whipping during relatively light winds at Niagara Falls should be sought.

He suggested that so long as the cables were smoothly glazed on one side, and left rough (as in stranding) on the other side, there would be galloping due to Magnus Effect. If later due to moving around freely under these conditions, the cables became all coated over, then that particular span would show much less movement.

Lift of Partially Coated Conductors Investigated

Archer urged the taking of measurements, to confirm these assumptions, in a wind tunnel which was available at the University of Toronto. A specimen was prepared; it consisted of a piece of conductor left rough over one-half of its circumference. The other side was made smooth and varnished, approximating the partial coating of glaze which was noticed on the conductors. Experiments of this sort had already been suggested by Knowlton.[2] This was done and the results are indicated in Fig. 1. It is clear from the diagram that for certain quite small angles of rotation of the coated conductor in a steady wind the variations in lift and in depressing effects are relatively large and rapid.

In Fig. 1, it can be seen that on either side of zero degrees, there are changes in lift from minus 0.085 to plus 0.088, and from minus 0.13 to plus 0.07, being 15 per cent to 20 per cent of the weight of the cable. Catenaries, especially when supported by suspension insulators which readily swing away from and into the span, are not very stable when subjected to rapidly reversing vertical forces even if these forces are relatively small, as compared with the weight of the cable and as in the case of the cotton line may be expected to dance or gallop as a result of application of the relatively small but rapidly reversing forces. There was as a result of this investigation considerable evidence that the partial coat of glaze might be a sufficient explanation of the extraordinary conditions observed at Niagara Falls.

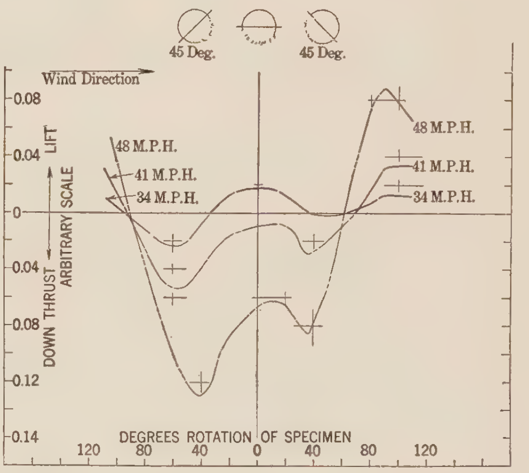

Fig. 1—"Lift" Curves for Conductors Thinly Glazed One Side Only

Half surface smoothed with plasticene to represent ice

1. High-Tension Congress Report, Paris, 1927.

Relation between Glaze Storms and Galloping and Classification of Data

A study of reports by over 30 observers, including those reported by Archbold[2] which is by far the largest group, establishes the fact that in 78 to 80 per cent of the cases reported sleet existed on the wires, was being deposited in the district, or might be expected because the temperature was 32 deg. and the weather misty and damp.

Archer's observations cover two classes of whipping, the first being in warm weather with violent winds and with flyings moving about freely. He expected that the wires would be short-circuited or grounded, because of comparatively restricted clearance. They, however, did not go out of service.

In the other case so far as weather was concerned, there was no reasonable explanation immediately available as to why the conductors should be so "possessed," or why some wires in a span were quiet and others moved vertically as much as or more than the total sag at rest. Fine mist or rain was falling and there was a wind storm; but no such wind storm as had recently been observed at Whitby. So long as the weather conditions continued as they were, however, there was no likelihood of the circuits remaining in service at Niagara.

It is therefore proposed that for purposes of analysis, reports of abnormal movements in conductors shall in general be classified and so far as can be done reasonably, grouped with one or the other of these two observations of which the latter typifies the larger group. If ice is to remain on the conductors for any length of time, then so far as outages are concerned the group represented by the observations at Niagara Falls is by a considerable amount the more important.

Varying Shapes and Cross-Sections of Ice-Coating on Conductors

During several days, centering around December 19, 1929, a rather extended and troublesome sleet storm occurred in New York and Ontario districts, focusing, in its effects upon transmission lines, on the Niagara River area. There were in this area many opportunities, extending in some cases over more than one day, to study galloping conductors and the effects of these extraordinary movements on conductors and structures. The writer was fortunate in being at Allanburg, near the mid-point of the Welland Canal, Fig. 3, on the morning of the 20th. With great difficulty because of ice on towers, cold weather, snow, and wind, repair men were restoring a 312,000-cir. mil A. C. S. R. conductor which had been burned off near the end of the middle third of a 630-ft. span. This circuit some 40 mi. in length had given practically uninterrupted service for 18 years, excepting occasional momentary outages due to lightning. Two wires of a 100-kv. circuit were in a nearly vertical plane with 8-ft. separation, being part of a triangular configuration.

The conductor which had parted, along with many other conductors and static wires forming parts of seven quite closely associated high-voltage circuits, were all coated with smooth ice of variable cross-section, which had apparently been considerably worn down by wind and weather, having been deposited a day or two previous. In some typical cross-sections which were about 2 in. long, there were two fairly sharp points at each end of the ice envelope. One of these was evidently a drip or series of icicles, and was a maximum radial distance of ¾ in. from the surface of the conductor. The other abrupt angle was opposite the drip and was not nearly so marked. It was generally not more than ⅜ in. radial distance from the surface of the conductor. Usually there was a thin coating of glaze on all sides of the conductor. To some, a typical cross-section might look like a small bird crouching or clinging close to the conductor.

The 312,000-cir. mil A. C. S. R. conductors remaining intact in this span were moving about so freely in a comparatively light wind, (30 mi. per hour at 75 deg. to line) that repair men were scarcely in position to report the circuits as available for operation or test under load even after repairs had been completed. So long as weather conditions continued as they were the phases with vertical configuration were not always clear of one another. With a loaded sag of 18 to 20 ft. equivalent to a uniform ice-coating of about 7/16 in. radial thickness, the conductors were moving through vertical distances reported, after study by several, as from 20 to 25 ft. There was a slow elliptical motion, with a small horizontal axis of the ellipse. The period was irregular but generally three seconds for a cycle. The suspension insulators were moving away from, and into, the span as much as 30 in. The cycle of insulator swing was about three seconds. In most cases, the whole span was moving upwards and downwards with irregular speeds, especially in the upper portions of the cycle. In other nearby spans, the conditions were much the same with some evidence of a sort of galloping; that is, one-third of a span would lift and as it reached its highest point and commenced to fall the central part of the span would be moving up towards its high point; and so on, giving the effect of a traveling wave. This continued until in the course of several hours, the wind changed.

All during this time, the 5/16-in. static wires on each of three nearly parallel lines of towers including this one, the pair of 4/0 copper conductor circuits, and six 605,000-cir. mil A. C. S. R. conductors of the third pair of towers, were all quiet; that is, they were swinging out of plumb about 20 deg. and in that position moving about only a little on account of a somewhat variable wind.

2. *Electrical World*, January 26, 1929, p. 199.

Effect of Wind upon Cable and Ice Having Irregular Outline of Cross-Section

From these observations, it was evident that it was necessary to study some of these irregular shapes and cross-sections in the wind tunnel. The succeeding cross-sections along the conductor were very irregular, resulting on account of the drip and icicles in a somewhat saw-toothed effect. A typical shape was chosen and a specimen 18 in. long was made of full-sized cross-section. As is customary in examining airplane models gravity was balanced out and the curves shown in Fig. 2 were secured for 25, 40, and 50 mi. per hour, these having been corrected to per foot basis so as to compare with recorded cable data. Then a curve for 60 mi. per hour was calculated and added.

With this type of cross-section, the resulting lifts and the pressing down were very much greater than indicated in Fig. 1. Selecting for study the extreme case of 60 mi. per hour, there is, for changes in rotation

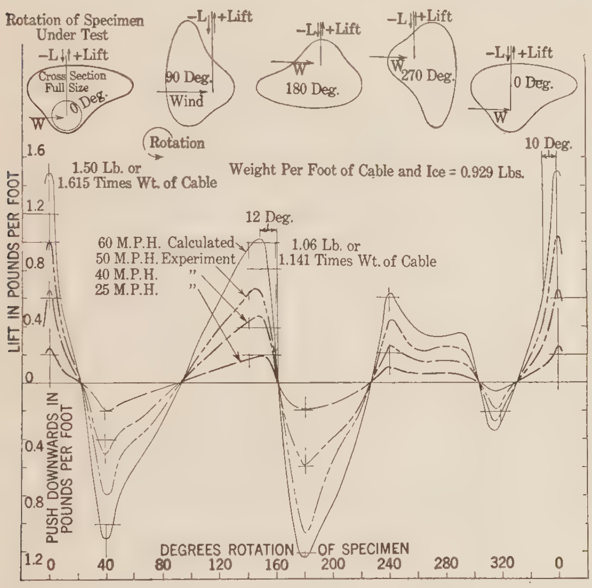

Fig. 2—"Lift" Curves for Special Shape of Ice-Coating on Conductors

Data from tests on model of ice covered transmission wire by Dept. of Mechanical Engineering, University of Toronto (Gravity balanced out)

of 10 deg., a total change in lift of from plus 0.65 lb. per ft. to plus 1.50 lb. per ft., or of 0.85 lb., or 0.91 times the weight, of the cable and ice combined. Taking another part of the curve, there is, for changes in rotation of 45 deg., a total change in lift of from minus 0.38 lb. to plus 1.50 lb.; this is 2.02 times the weight of the cable and ice combined. Examining lift only, it is evident that at 60 mi. per hour and at considerably lower velocities, there would be sufficient lift to carry the cable with its load upwards indefinitely so long as the angle of presentation to the wind could be maintained within close limits.

In angles of effective presentation of ice surface to wind variations of 10 deg. and 45 deg. are mentioned. The more effective lifts, however, are confined to much smaller changes of angles of presentation, just as in airplane work there is little margin in maintaining equilibrium at critical flying speeds. It would therefore appear that the neighboring copper conductors, the larger aluminum conductors, and the three ground wires including that one serving the conductors in question, did not naturally present that critical angle, limited, say, to 6 deg. in 360 (one in 60 chances) for effective lift. They remained relatively quiet, although they did carry somewhat similar ice coatings. The cables causing trouble were apparently poised so that the lift was effective when the forces due to horizontal wind pressure and gravity were stabilized. As the cable rises, due to the lift becoming effective, the angle of presentation is actually changed a few degrees because of rotation of pendulum of the catenary around the point of support of insulator at the tower. The tension in the conductor may have been so changed that there is also a slight rotation because of uncoiling of lay of the cable; this latter feature, however, has not been investigated. The result of this slight change of angle is that the cable is relieved of the upward force and falls by gravity. It may even be thrust down by the wind, the rotation and resulting change in presentation having gone through the neutral point of the lift curve.

Natural forces duplicating the lifting effect observed in galloping conductors have been demonstrated in the wind-tunnel and have been calibrated and recorded. The phenomena may be intelligently reproduced at will and may be studied and measured. Once problematic conditions can be duplicated experimentally in the laboratory and measured, they are in a fair way toward being understood and solved. These curves are submitted for further study with a view to ultimately disposing of a quite serious menace to continuity of service of important overhead trunk transmission lines.

Conclusion

The stated purpose of this paper was to record the steps necessary to reproduce the conditions observed in the field, and provide a yard-stick by which studies can be made to develop effective means of insuring service during sleet storms. To some extent at least this purpose has been accomplished. Some procedure should be developed by further studies which will be less hazardous, difficult, and inconvenient than that of overloading the circuits.

Acknowledgment

The suggestions made by Mr. E. G. Archer account very largely for the work done in preparing the data for this paper. His assistance in also assembling data for the article is gratefully acknowledged.

Abridgment of

Radio Telephone Service to Ships at Sea

BY WILLIAM WILSON[1] Member, A. I. E. E. and LLOYD ESPENSCHIED[2] Member, A. I. E. E.

***Synopsis.**—The paper discusses the American end of the ship-to-shore radio telephone system and the connecting equipment on board the SS. Leviathan. There is given an outline of previous work in this field and of the technical problem involved in the use of short waves. The station facilities which have been provided for this service on the New Jersey coast are described also the equipment which has been developed for the ship. Finally, the results are given of the first trip of commercial service of the Leviathan.*

THE ship-to-shore radio telephone system here described was opened for public service between the *SS. Leviathan* and the United States on December 8, 1929. This was the first extension of the public telephone service to a ship at sea, and enabled calls to be made between the vessel and any Bell System subscriber. The system as set up is intended primarily for giving telephone service to the larger passenger-carrying vessels as an extension to the wire network, and should be distinguished from the more simple uses which have been made of radio telephony in the marine field, such as enabling a coastal station operator to talk with coast guard vessels, fishing trawlers, etc.

It is significant of the wide-spread interest in this service that developments have also gone forward rapidly on the European side where the British, Germans, and French are preparing coastal stations and equipping some of the larger ships for public telephone service. The British have initiated service to the *SS. Majestic* and the *SS. Olympic*, and service to these vessels has been extended also from the American side. Before the summer is over, it is likely that half a dozen of the larger transatlantic vessels will be undertaking this service, connecting with both the American and the European telephone networks.

Early Developments

Following the long-distance, point-to-point radio telephone experiments of 1915, what is believed to have been the first trial of two-way radio telephony from the wire telephone system to a vessel at sea was conducted by Bell System engineers in 1916, in cooperation with the Navy Department. In the years 1920-1922 there was undertaken an extensive development of ship-to-shore radio telephony, looking toward the linking of ships at sea with the land line telephone network.[3] At that time there was built a coastal radio telephone station at Deal Beach, N. J., and several ships were equipped on a trial basis. Extensive engineering tests were made and a number of demonstrations carried out which proved the physical feasibility of establishing such connections at that time. The waves in the range of 300-500 meters, which had been used in these early trials, were soon thereafter assigned for broadcasting.

More recently the development of short-wave radio systems has greatly increased the message carrying capacity of the radio spectrum, and has made it feasible to maintain communication over a greater range of distances than was previously practicable for ships. Transoceanic radio telephone services have been inaugurated, and with the large increase in steamship travel, there has arisen a renewed interest in the extension of telephone service to ships at sea.

For purposes of point-to-point as well as for ship-to-shore telephone services, and as part of a general program intended to obtain fundamental data upon short-wave transmission, there was undertaken a series of measurements of the strength of electric fields received aboard ship from a shore transmitter. These tests were first made in 1925 on vessels running between New York and Bermuda. Further measurements were made in subsequent years on other ships.

Along with this study of transmission conditions there was carried on the development of short-wave apparatus technique for telephony. The first application was in the field of point-to-point transatlantic operation; and the considerable art built up there, including the design of transmitters, receivers, directive antennas and the working out of two-way operating methods, served as a very useful basis from which to develop the coastal and ship stations for the maritime system.

With this background of development, preparations were made to set up a two-way, short-wave radio telephone system for commercial service. This service was centered upon New York because of the large concentration of ocean-going traffic at that port.

The Technical Problem

One of the most important problems to be solved in the design of a short-wave system is that of determining the frequencies necessary for giving the service involved. The frequencies which are best suited to the different distances, time of day, and season of the year for trans-

1. Bell Telephone Laboratories, New York, N. Y.

2. American Telephone and Telegraph Company, New York, N. Y.

3. "Radio Extension of the Telephone System to Ships at Sea," by H. W. Nichols and Lloyd Espenschied, *I. R. E. Proceedings*, 1923, Vol. 11, No. 3.

Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.

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mission over the North Atlantic are indicated in the curves of Fig. 2. Fortunately, there is a considerable band on each side of the curves shown for the longer distances in which good transmission can be obtained, and this enables one to choose in the short-wave range a small number of frequencies which are adequate to cover the conditions. Actually, it is found that a set of about four frequencies is required to cover the North Atlantic.

By reason of the fact that the transmission appears

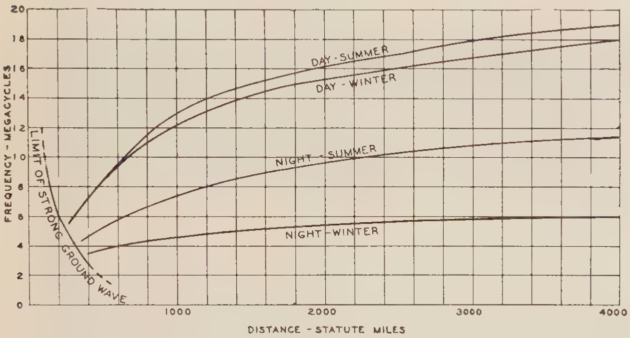

FIG. 2—DISTANCE-FREQUENCY CHARACTERISTIC

to take place in the upper regions of the earth's atmosphere, for distances greater than a few hundred miles, these characteristics obtain irrespective of whether the transmission is over water or land. Closer in to the transmitting station, however, there is the so-called surface component, the attenuation of which is much less over sea water than over land. It will be seen that the surface wave may be relied upon for distances of the order of 200-300 mi., for frequencies of about 4000 kc. The transmission of this component is much more stable and reliable than is the transmission of the sky wave. It seemed important, therefore, to utilize the surface wave to the maximum extent possible. Measurements have shown that to avoid seriously sacrificing the effectiveness of the surface wave, it is necessary to locate the coastal transmitting and receiving stations immediately upon the seacoast or a salt-water bay.

An important factor in connection with radio reception on shipboard is that of electrical interference. The operation of the electrical machinery and the radio telegraphic services produces interference in a shipboard receiver which is much in excess of that normally encountered in a suitably located shore receiving station. Furthermore, there is on the ship another source of disturbance which is due to charging and discharging of various parts of the rigging in the strong electromagnetic fields of the various radio transmitters. These factors make it desirable to employ at the shore end as powerful a transmitter as is available, and to use whatever benefit is obtainable from antennas designed to be directive along the transatlantic ship lanes. A transmitting set of the type used in transatlantic communication, but adapted for ship-to-shore wavelengths, is therefore employed.

Since the shore receiver may be located in a comparatively quiet situation, and since use can also be made of directive receiving antennas, it is not necessary to transmit as large an amount of power from the ship as from the shore. The actual power radiated by the *Leviathan's* transmitter is of the order of 500 watts.

THE SHORE SYSTEM

The general set-up of the system is illustrated in Fig. 3. The coastal stations, sending and receiving, are located about 60 mi. south of New York on the New Jersey shore, at Ocean Gate and Forked River.

In general, the whole coastal station, including the transmitting and receiving units, together with the wire line connections and control position in New York, is similar to one end of a transatlantic point-to-point circuit. The transatlantic facilities have been described in previous papers[4] and reference should be made to them for more detail than is given below. The transmitting set has a power of a 15-kw. output of unmodulated carrier and is capable of delivering 60-kw. peak power. Actually, a similar transmitter, located two miles inland at Deal Beach, is being used for this service pending the completion of the new transmitting station on the waterfront at Ocean Gate.

The receiving station at Forked River has been in operation since the opening of commercial service last December. The receiver is of the double-detection type, of high gain and selectivity, and employs screen-grid tubes. It is provided with automatic gain control. The apparatus at the receiving station includes not only the receiving set proper but also the equipment which is

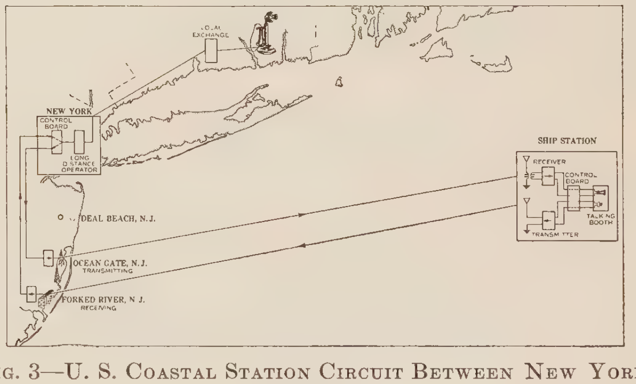

FIG. 3—U. S. COASTAL STATION CIRCUIT BETWEEN NEW YORK AND SHIP

required for monitoring the circuit and for connecting with the wire line into New York. The receiving directive antennas are of the same general type as those used in the transatlantic system, but less sharply directional. A photograph of the station at Forked River and two of the antennas is shown in Fig. 8.

The control and operating terminal equipment in New York is identical with that in use on the trans-

4. Papers on *Transatlantic Telephone Service*, by Messrs. Miller, Bown, Oswald and Cowan, presented at Winter Convention of the A. I. E. E., New York, N. Y., January 27-31, 1930.

oceanic radio telephone circuits. The control positions include voice-current operated switching devices which prevent the speech received from the ship from being re-radiated from the shore transmitting station and permit independent adjustment of amplification in the circuits leading to the transmitting and receiving stations. This enables full modulation of the transmitter to be obtained for over-riding noise on the ship despite variations in speech volume received from different land line subscribers.

The circuit terminates as an operating facility before a traffic operator at one of the long-distance telephone boards in New York. This telephone operator talks directly with the ship operator, passes and receives information as to calls, and is generally responsible for completing the connection between the ship circuit and the land line subscriber. She is assisted by a second operator who is concerned more particularly with the land line subscribers, themselves, getting in touch with and holding land line subscribers for inbound calls, answering inquiries and recording calls outbound to ships.

Fig. 8—Illustration Forked River Station with Antenna

The Ship Station

The *Leviathan's* radio transmitter is designed to supply about 500 watts, 80 per cent modulated radio frequency power to an antenna at frequencies from 3000 to 17,000 kc. A schematic of the circuit is shown in Fig. 11. The transmitter unit comprises a crystal oscillator and associated amplifiers designed to maintain the carrier frequency within close limits; namely, 0.01 per cent. This minimizes interference with other services, facilitates the establishment of contact between the ship and shore stations, and obviates the necessity for frequent retuning of the shore receiver.

The thorough electrical shielding which is necessary between amplifier stages to prevent singing makes the changing of coils, required for the changing of wavelengths, very unhandy. Hence, the crystal control and amplifier system, except in the last stage, is provided in duplicate, one amplifier system being used for the two longer and the other for the two shorter waves. Wave changing is then accomplished by connecting the proper amplifier to the power stage and resetting the output circuit of the power stage.

The quartz plates used in the crystal control system are circular, approximately one inch in diameter, and are clamped rigidly in the holder. The holder, with its crystal, is mounted in a small oven, the temperature of which is held constant at 50 deg. cent. to better than +0.1 deg. cent.

As shown in the figure, the crystal is connected between the grid and filament of a five-watt vacuum tube. The radio frequency voltage developed by the crystal oscillator is applied directly to the grid of a 7½-watt screen-grid tube which can be used either as an amplifier or a frequency doubler. The output of this tube, except in the case of the higher frequencies, is applied directly to the grid of a 50-watt screen-grid amplifier and thence to the final amplifier stage. For the higher frequencies, a second frequency doubler is switched into the circuit. The power amplifier consists of an air-cooled,

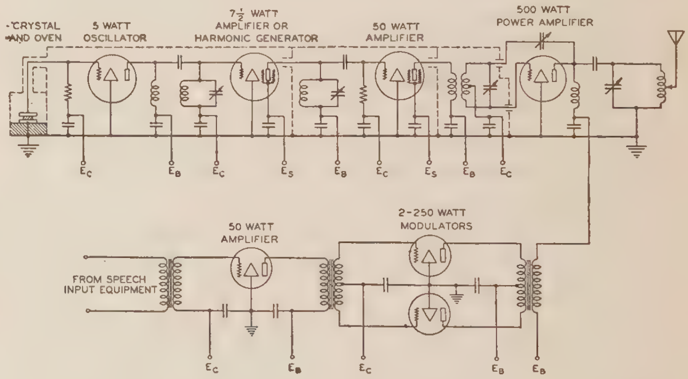

Fig. 11—Ship Transmitter's Schematic Diagram

three-element, one-kilowatt tube. Neutralization is accomplished by the familiar balancing arrangement shown in the figure. Modulation takes place in the plate circuit of the final amplifier stage by means of two 250-watt tubes, connected push-pull and fed by a 50-watt amplifier. The power supply is obtained from motor-generator sets operated from the 110-volt d-c. ship supply.

A reduction of the receiving disturbances due to stray noises and better discrimination against the transmitted carrier is obtained if the transmitting and receiving antennas are widely spaced. In the case of the

Leviathan installation, the transmitter and receiver are located in the same room and the transmitting antenna is located directly above the radio room, between the second and third stacks, with the receiving antenna placed as far behind the third stack as possible. The receiving antenna is connected through a suitable step-down circuit to a shielded transmission line and thence to the receiver, the receiver itself being very thoroughly shielded to avoid direct interference from the transmitter. On account of limited space, only two receiving antennas are provided to handle the four frequencies, each antenna representing a compromise between the most efficient antennas which could be put up to handle the separate wavelenghts.

Fig. 13—Receiver on SS. Leviathan

The receiver itself is of the double-detection type, using heater type tubes throughout. Screen-grid tubes are used for the first detector and intermediate frequency amplifiers and three-element tubes in the remaining positions. A reproduction of a photograph of the receiver and associated voice-frequency equipment, as it is installed on the *Leviathan*, is shown in Fig. 12. The high-frequency selective system consists of four separately shielded, tuned circuits, coupled by small capacities. The purpose of these selective circuits is to prevent overloading in the first detector. The intermediate frequency amplifier stages are coupled by means of double tuned circuits. The use of properly designed circuits of this type makes it possible to obtain a high degree of selectivity against undesired frequencies while obtaining sufficient band width to maintain ease of tuning and to pass the desired frequencies. Automatic gain control is provided in which a certain amount of the carrier is taken at the end of the intermediate frequency stages, amplified, rectified, and applied to the grid of the first detector in such a manner that an increase in the intermediate frequency output brings about a reduction in the total set gain, and vice versa.

The voice-frequency equipment for controlling the circuit is to be seen also in Fig. 13. It consists of repeaters, volume-control devices, and volume indicators, by means of which the levels of the incoming and outgoing signals can be properly adjusted. Keys are provided which enable the technical operator in the radio room to talk either over the radio circuit or to the ship subscriber. On a lower deck is located the subscriber's booth and a position for an attendant. The attendant has facilities by which he can talk either to the subcriber or to the technical operator and has a connection with the ship's telephone system for the purpose of locating persons on the ship and calling them to the telephone booth.

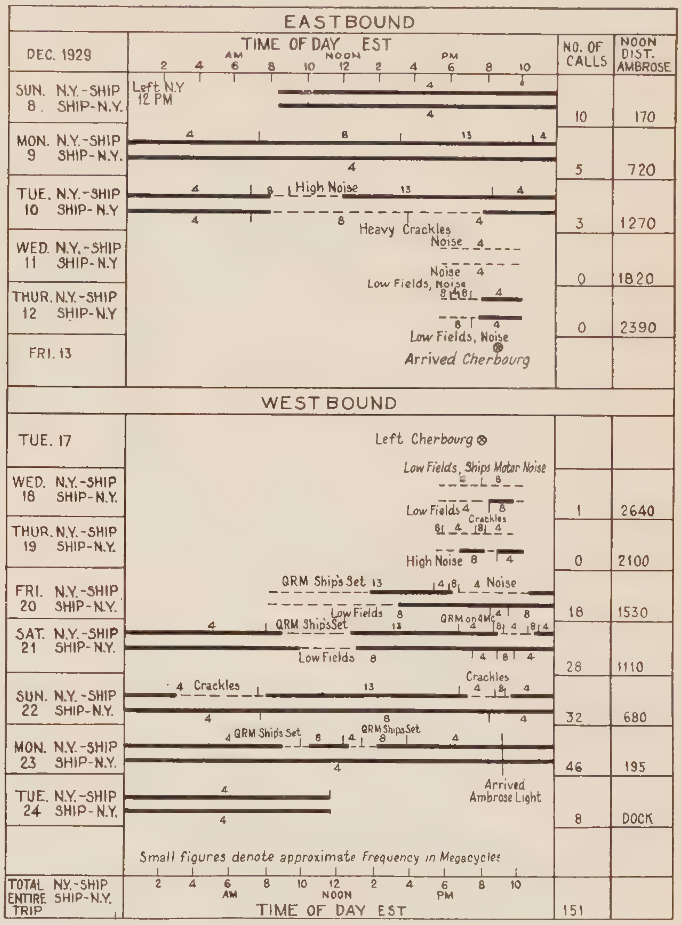

Fig. 16—Transmission Results between SS. Leviathan and New York

The Wavelength Situation and Simultaneous Telephone and Telegraph Operation

Communication between ship and shore is carried out by the use of a pair of frequencies, one for transmission in each of the two directions, separated from each other by about 3 per cent. The specific frequencies which were first assigned by the Federal Radio Commission to the shore station and the *Leviathan* were in the absence of any comprehensive wavelength plan for this new service necessarily chosen on more or less of a makeshift basis. The Commission has recently had under study the setting up of more adequate provisions

for ship-to-shore telephone channels, whereby it is hoped a series of frequencies may be designated for telephone service exclusively and whereby there may be established the relation between the telephone and the telegraph frequencies necessary for the avoidance of interference between the two services. Difficulties of fitting in the two services were encountered in the early work on the *Leviathan* and although the problem has not yet been worked out to final solution, sufficient progress has been made in cooperation with the engineers of the Radio Corporation of America, to enable the telegraph and telephone services to be conducted simultaneously without undue interference. The whole question of marine frequency allocations is in need of being further developed not merely on a national but also on an international basis.

Transmission Results

The transmission results of commercial service which have been obtained with the *SS. Leviathan* on her first trip are summarized in Fig. 16. It will be noted that practically continuous 24-hour communication was maintained for distances within 1000 mi. of the shore, corresponding to two days out. The service at greater distances was more intermittent, due largely to the fact that during this first trip the effort was concentrated on the more important nearer-in distances, and the ship was not prepared to transmit on frequencies above 8000 kc. The service proved to be much in demand by the passengers, as is indicated by the number of calls completed each day, particularly on the return trip. A like number of test and demonstration calls was made during the voyage.

Abridgment of

Reduction of Eddy Current Losses by the Inverted Turn Transposition and the Twisted Lead Transposition

BY JOHN M. LYONS*

Associate, A. I. E. E.

Synopsis.—*The first section of the paper contains a brief review of the general theory underlying the determination of extra copper losses in armature windings carrying alternating current. Simplified methods of calculation are then described.*

The second part extends the study of the inverted turn transposition to the special case of three-phase windings, with two phases connected in series to form a single-phase winding and the third phase left idle. Formulas and tables are presented to show what reductions in copper losses may be expected for this connection, and to aid in deciding what type of transposition is best for a given winding.

The final section of the paper deals with the twisted lead transposition, and presents formulas and tables showing reductions in extra losses to be gained from this method of inversion and connection. Details of the derivations of the formulas and examples of the use of the twisted lead transposition are contained in appendixes at the end of the paper.

* * * * *

I. Introduction

The problem of determining the extra copper losses in rectangular conductors composing the armature windings of large alternators has been covered in detail in the well-known papers listed in the references. From these and many other investigations several methods have been adopted commercially for reducing the parasitic eddy current losses and the extra heating which they produce. The methods now in use group themselves into two general classes. One class includes transpositions of the conductor laminations in the slot, and the second includes inversions or twists of whole conductors or leads in the end portions. This paper is concerned only with the second class.

The inverted turn transposition, described by I. H. Summers[1] in a previous Institute paper, is now used to advantage on practically all multi-turn coils in large generators. The loss reductions to be expected from the use of this transposition in standard two-phase and three-phase windings can be found from the formulas and tables contained in Mr. Summers' paper.

This transposition can also be applied equally well to various special windings, and one purpose of this paper is to extend the general treatment to cover one such case. The winding to be considered is the standard three-phase winding in which two-phases are connected in series to form a single-phase winding, and the third phase is left idle. Formulas and tables for finding loss reductions in such a case are given herein, while the general method of calculating these factors with the latest simplifications is detailed in the complete paper.

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1. *Reduction of Armature Copper Losses*, by I. H. Summers, A. I. E. E. Trans., Vol. 46, 1927, p. 101.

An alternative method of transposing multi-turn coils is available when the inverted turn method cannot be used. This is the so-called "twisted lead transposition," which, as the name suggests, consists of a 180-deg. twist in one lead of each armature coil. To make the inversion effective, the various levels of conductor laminations are insulated from each other throughout each phase belt. The salient results of the mathematical investigation of loss reduction effected by this device are contained in the formulas and tables presented in Section V. Various types of windings and coil groupings are treated in the complete paper, including the special case of the three-phase winding connected single-phase with one leg idle.

II. General Theory

A brief review of the fundamental theory underlying the determination of extra copper losses in rectangular conductors is essential to a complete discussion of the problem. The basic cause of extra copper losses in slot-wound conductors carrying alternating current is the uneven distribution of the current over the cross-section. The flux linkages, and hence the reactance, are greatest at the bottom of the conductor, and least at the top. The current is in effect forced toward the top of the conductor, since the same voltage drop occurs along all the elements of the conductor between points where the elements are solidly joined. This means that the copper losses at the top are greatly in excess of the average, and while the losses at the bottom are less than the average, the total losses in the conductor are greater than occur with the same total uniform current. Likewise, in the several turns in the slot, the extra loss is greatest in the top conductor and least in the bottom one.

Reference to the works of various authors[2, 3] who have investigated this effect will provide the formulas and equations for current density and extra copper loss, together with the simplifying assumptions used. It will be noted that four factors enter into all equations for current density and copper loss. These are: (1) frequency; (2) ratio of total copper width to slot width; (3) resistivity of copper; (4) total depth of conductor. These variables are generally collected into one factor D according to the equation:

$$D = 1.19 \left[\frac{f}{60/\text{sec.}} \right]^2 [b\, r\, c\, (n\, d/\text{in.})^2\,]^2 \qquad (1)$$

which holds good for copper at 75 deg. cent. In this formula:

f = frequency

$$b = \frac{2 \times \text{core length}}{\text{means length of turn}}$$

$$r = \frac{\text{copper width}}{\text{slot width}}$$

$$c = \left[\frac{\text{gross strand depth}}{\text{net copper depth of strand}} \right]^2$$

n = number of strands depthwise in conductor

d = net copper depth of strand.

The extra copper loss in any conductor depends both on its own current, and on the total slot current below it. The latter in turn depends on the number of turns per coil and on the phase displacements between currents in upper and lower coil sides. A single factor L (see Table I) takes care of these variables. The approximate formula for extra copper loss expressed as a percentage of ohmic loss is

$$k = (4 + 15\, L)\, D \qquad (6)$$

III. Inverted Turn Transpositions in Single-Phase Windings

The loss reductions effected by the inverted turn transposition in the special single-phase winding under consideration vary from those in standard polyphase windings because of the different phase angles between currents in the upper and lower coil sides. In the single-phase winding, the currents may only be in phase, 180 deg. out of phase, or the lower coil may carry no current if it is in the idle phase. The values of L for these combinations for the various types of transposition are shown in Table I.

By substituting the value of L for untransposed coils into Equation (6), it will be found that when the coils are transposed, the substitution of a new value of L will result in a reduction in extra loss according to the ratio

$$F = \frac{16 + 60\, L}{15\, m^2 + 1} \qquad (9)$$

where m is the number of turns per coil, and L is the new value due to the transposition. This is the general formula on which Table II is based. The Table covers all ordinary numbers of turn per coils and all coil pitches.

Several significant facts can be seen from an inspection of the table and curves. In particular, Type II transpositions are most effective for coils with even numbers of turn. Type III transpositions are to be preferred for coils with odd numbers of turns, especially when the pitch lies between 33⅓ per cent and 66⅔ per cent. In general types IV and V are not so effective as Types II and III, and are to be used only when space prohibits the use of Types II and III in coils with many turns.

The special case of single-layer windings with standard coils of Type I can easily be treated by referring to Table I. For all coils of this type of winding $I_2 = 0$, and hence for standard coils without transposition.

$$L = -1/4$$

For this value of L the extra losses in a given winding with barrel-type coils are a minimum. No reductions

TABLE I

VALUES OF "L" FOR POLYPHASE AND SPECIAL SINGLE-PHASE WINDINGS

Type	Description of winding	Turns per coil	Value of L for polyphase winding	Value of L for single-phase winding: $\mathbf{I}_2 = m\,\mathbf{I}_1$	$\mathbf{I}_2 = -m\,\mathbf{I}_1$	$\mathbf{I}_2 = 0$
I	Multi-turn coil. Two coil sides per slot. Involute at each end. (Standard coil)	Either Even or Odd	$\frac{m^2-1}{4}$	$\frac{m^2-1}{4}$	$\frac{m^2-1}{4}$	$-1/4$
II	All turns inverted on end opposite connections	Even	$-1/4$	$-1/4$	$-1/4$	$-1/4$
		Odd	$3/4 - \sin^2\left(\frac{\theta}{2}\right)$	$3/4$	$-1/4$	0
III	All turns inverted on connection end.	Even	0	0	0	0
		Odd	0	0	0	$-1/4$
IV	Top half turn in upper coil side only inverted on connection end	Either Even or Odd	$\left[\frac{(m-1)(m-2)}{m}\right]\left[\left(\frac{m^2-5m+2}{4m}\right)+2\sin^2\left(\frac{\theta}{2}\right)\right]$	$\left[\frac{(m-1)(m-2)}{m}\right]\left[\frac{m^2-5m+2}{4m}\right]$	$\left[\frac{(m-1)(m-2)}{m}\right]\left[\frac{(m+1)(m+2)}{4m}\right]$	$\frac{(3m-2)(m-2)}{4m^2}$
V	Bottom half turn in upper coil side only inverted on end opposite connections	Either Even or Odd	$\left[\frac{m^4-4m^3+m^2+4m+1}{4m^2}+\frac{m-2}{m}\sin^2\left(\frac{\theta}{2}\right)\right]$	$\left(\frac{m^4-4m^3}{4m^2}\right)+\left(\frac{m^2+4m+1}{4m^2}\right)$	$\left(\frac{m^4-4m^3}{4m^2}\right)+\left(\frac{5m^2-4m+1}{4m^2}\right)$	$\frac{1-m^2}{4m^2}$

Note: Top always refers to open end of slot.

can be made in the losses by any of the transpositions treated in this paper. Single-layer, one-turn coils generally require reduction in extra losses, and such coils should be made up of half-turns bars with laminations transposed in the slot portion by well-known methods.

V. Reduction of Extra Circulating Current Losses by the Twisted Lead Transposition

The circulating currents in any winding can be reduced by increasing their path length. If several coils with insulated strands have their leads connected together in such a way that the strand levels remain insulated throughout the whole coil group, the percentage of extra loss is less than in a single coil with

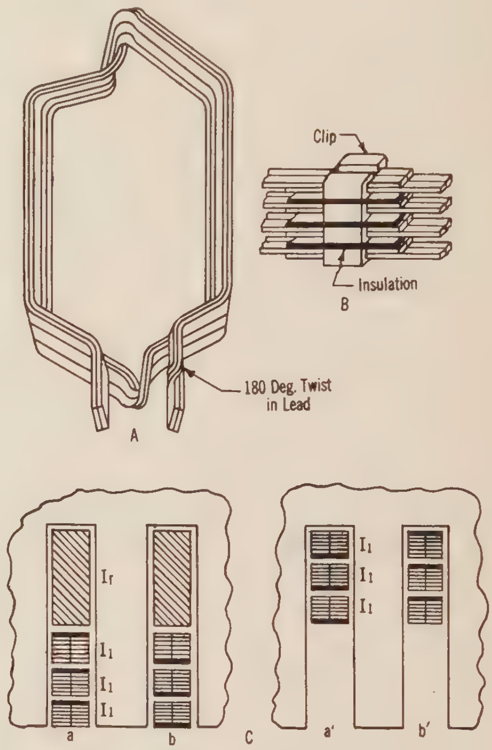

Fig 14—Twisted Lead Transposition of Barrel Type Coils

A. Standard multi-turn coil with twisted lead
B. Simplified detail of insulated clip connections
C. Conventional slot cross-sections of two consecutive coils $a\,a^1$ and $b\,b^1$ in a phase belt

standard connections. At the same time, twisting one lead of each coil through 180 deg. before clipping to the next, as shown in Fig. 14, results in a partial equalization of the reactive voltages induced by the slot leakage fluxes, and produces loss reductions comparable to the inverted turn transpositions.

The twisted lead transposition described above was suggested by Mr. M. A. Savage, one of the author's associates. It has been used successfully on large alternators, where space prohibited using the inverted turn transposition. Approximately 15 machines have been built since then with armature windings transposed by this method. Although this is a relatively small number compared to the number using the

inverted turn transposition, it should be noted that in machines where the twisted lead method is applied it is indispensable in reducing extra losses. An added impetus has been given to its use by the development of methods of calculating the ratio of the circulating current loss in such a winding to the loss in the same number of turns per coil, t is the number of coils in the phase belt considered, and u is a factor depending on the way the phase belt is split up as regards phase angles between upper and lower coil sides. This factor can have any one of three values, namely, 0, 1, 2. Table III gives a summary of the possible groupings of

TABLE II

REDUCTION FACTORS FOR CIRCULATING CURRENT LOSSES OBTAINED WITH INVERTED TURN TRANSPOSITIONS

Three-Phase Windings Connected Single-Phase with One Phase Idle

Turns per coil	Type of Transposition															
	II				III				IV				V			
	Pitch				Pitch				Pitch				Pitch			
	0	1/3	2/3	3/3	0	1/3	2/3	3/3	0	1/3	2/3	3/3	0	1/3	2/3	3/3
2	0.0164	0.0164	0.0164	0.0164	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.0778	0.0778	0.0778	0.0778
3	0.00736	0.0625	0.2833	0.449	0.1176	0.0625	0.0625	0.1176	0.607	0.405	0.114	0.0197	0.2035	0.112	0.0380	0.0564
4	0.00415	0.00415	0.00415	0.00415	0.0664	0.0664	0.0664	0.0664	0.768	0.456	0.0820	0.0197	0.319	0.1635	0.1015	0.195
5	0.00266	0.0226	0.1023	0.1620	0.0425	0.0226	0.0226	0.0425	0.845	0.475	0.0929	0.0809	0.411	0.208	0.160	0.315
6	0.00185	0.00185	0.00185	0.00185	0.0295	0.0295	0.0295	0.0295	0.891	0.485	0.1157	0.1525	0.482	0.242	0.205	0.408
7	0.00136	0.0115	0.0523	0.0828	0.0217	0.0115	0.0115	0.0217	0.920	0.491	0.1417	0.222	0.540	0.271	0.242	0.482
8	0.00104	0.00104	0.00104	0.00104	0.0166	0.0166	0.0166	0.0166	0.939	0.494	0.1659	0.283	0.586	0.294	0.270	0.539
9	0.00082	0.00695	0.0316	0.0501	0.01307	0.00695	0.00695	0.01307	0.950	0.495	0.1884	0.337	0.625	0.313	0.2935	0.586
10	0.00067	0.00067	0.00067	0.00067	0.01063	0.01063	0.01063	0.01063	0.960	0.497	0.2080	0.383	0.655	0.328	0.3125	0.624

TABLE III

VALUES OF "u" FOR TWISTED LEAD TRANSPOSITION

<table>
<tr><td colspan="5">Phase belt divided into two parts, each having a different phase angle between currents in top and bottom coil sides.</td><td colspan="3">All coils in phase belt have same phase angle between currents in top and bottom coil sides.</td></tr>
<tr><td rowspan="2">Both parts have even number of coils. Any number of phases.</td><td colspan="2">Both parts have odd number of coils</td><td colspan="2">One part has even number of coils. Other part has odd number.</td><td colspan="2">Total number of coils per phase belt is odd.</td><td rowspan="2">Total number of coils per phase belt is even.</td></tr>
<tr><td>Three-phase and special single-phase</td><td>Two-phase</td><td>Any number of phases except single-phase with the odd number of coils having $I_2 = 0$</td><td>Single-phase with the odd number of coils having $I_2 = 0$</td><td>Any number of phases except single-phase having $I_2 = 0$ in whole belt.</td><td>Single-phase with $I_2 = 0$ over whole belt.</td></tr>
<tr><td>$u = 0$</td><td>$u = 1$</td><td>$u = 2$</td><td>$u = 1$</td><td>$u = 0$</td><td>$u = 1$</td><td>$u = 0$</td><td>$u = 0$</td></tr>
</table>

TABLE IV

REDUCTION FACTORS TO BE APPLIED TO EXTRA CIRCULATING CURRENT LOSSES WHEN TWISTED LEAD TRANSPOSITION IS EMPLOYED

Turns per coil		$u = 1$												$u = 2$		
		Coils in phase belt												Coils in phase belt		
	$u = 0$	1	2	3	4	5	6	7	8	9	10	11	12	2	6	10
2	0.0164	1.00	0.262	0.126	0.078	0.0557	0.0438	0.0365	0.0318	0.0285	0.0252	0.0245	0.0232	0.508	0.071	0.0361
3	0.00735	1.00	0.256	0.118	0.0694	0.0470	0.0349	0.0276	0.0229	0.0196	0.0173	0.0155	0.0143	0.504	0.0625	0.0272
4	0.00415	1.00	0.253	0.115	0.0664	0.0440	0.0318	0.0245	0.0197	0.0164	0.0141	0.0124	0.0111	0.502	0.0595	0.0241
5	0.00266	1.00	0.252	0.1135	0.0649	0.0426	0.0303	0.0230	0.0182	0.0150	0.0126	0.0109	0.0096	0.5015	0.0582	0.0226
6	0.00185	1.00	0.251	0.113	0.0641	0.0417	0.0296	0.0222	0.0174	0.0142	0.0118	0.0101	0.0088	0.501	0.0572	0.0218
7	0.00136	1.00	0.251	0.112	0.0638	0.0413	0.0291	0.0217	0.0170	0.0137	0.0113	0.0096	0.0083	0.5005	0.0568	0.0213
8	0.00104	1.00	0.251	0.112	0.0635	0.0410	0.0288	0.0214	0.0167	0.0134	0.0110	0.0093	0.0080	0.500	0.0565	0.0210
9	0.00082	1.00	0.251	0.112	0.0633	0.0408	0.0286	0.0212	0.0164	0.0132	0.0109	0.0091	0.0078	0.500	0.0564	0.0208
10	0.00067	1.00	0.251	0.112	0.0631	0.0406	0.0284	0.0210	0.0162	0.0130	0.0107	0.0089	0.0076	0.500	0.0564	0.0206

winding untransposed. The formula which expresses this ratio is as follows:

$$F = \frac{15\,u\,(m/t)^2 + 1}{15\,m^2 + 1} \qquad (11)$$

This is a remarkably simple formula considering the complexity of the problem. In the formula, m is the the coils in single-phase, quarter-phase, and three-phase windings, with the corresponding values of u.

The reduction factors to be expected from the twisted lead transposition are shown in Table IV. The table covers only the usual range of turns per coil and coils per phase belt. The reduction factors for other conditions can easily be calculated from Table III and

Equation (**11**). The procedure for finding reductions in circulating current losses with the twisted lead transposition reduces, therefore, to checking what part of Table III describes the winding or phase belt, noting the value of u, and going to Table IV or Equation (**11**) for the reduction factor corresponding to the given values of m and t. In the general case of a winding with a fractional number of coils per pole per phase, it is necessary to first lay out the winding in order to see how many coils belong to each phase belt under each pole, and how the belt is split up. A reduction factor can then be found for each phase belt, and all these factors averaged to give the factor for the whole winding.

Comparing Table IV with Table II in this paper, and Table II in Reference (1), it is apparent that in general there is little if any sacrifice involved in using the twisted lead transposition in those cases where space or other reasons prohibits the use of the inverted turn transposition.

The unavoidable extra cost involved in clipping together the individual laminations of deep conductors can be appreciably reduced by bunching together two or three strand levels and clipping these bunches together. However, an extra loss is thus developed, which increases rapidly as the depth of the group increases. Hence the grouping should be a compromise between cost of connection and tolerable extra loss.

VI. Conclusion

The study of the inverted turn transposition, begun in the previous paper referred to in the Bibliography, has been extended to cover the special single-phase case of two phases in series and one leg idle. The twisted lead transposition has been described and analyzed to show its effect on extra losses, with the result that its use can now be definitely recommended in cases where other transpositions are impracticable.

Acknowledgment

The author wishes to acknowledge with appreciation the many important contributions to this paper by Mr. I. H. Summers, especially in the development of the formula for reduction in extra loss by the twisted lead transposition. The author also wishes to express his appreciation of the many constructive suggestions and criticisms offered by Mr. P. L. Alger.

Abridgment of

Rural Line Construction in Ontario

BY R. E. JONES[1]

Member, A. I. E. E.

Synopsis.—*This is a description of a large rural distribution system with some 4800 mi. of primary circuit. The history of the system is given from its inception as a few scattered extensions of town systems up to the present. The paper covers in detail the various forms of construction in use with the reason for their adoption. Comparison of lines are given with various span lengths and voltages. An 8000/4600-volt system has been adopted for part of the district and it is described in detail. In one area, a considable quantity of underground cable has been installed at a cost for single-phase not much greater than for an overhead line.*

The Southern part of the Province of Ontario has been divided into a large number of Rural Power Districts, each of such a size as to be economically fed from one point.

Each year an increasing mileage of rural line has been erected until at the end of 1929 there were in operation 4835 mi. For 1930, an additional 1500 mi. of rural line is projected.

Voltage

Most of the districts are supplied from an existing substation which in turn is fed at 13,200, 22,000, 44,000 or 110,000 volts. The secondary voltage of these stations is generally 4000/2300 star four-wire with neutral grounded at many locations, although in some cases the 2300-volt delta connection is used.

As the length of the lines, as well as the load, increased, it became a necessity to improve regulation either by an increase in the size of conductors or in the voltage.

Consideration was given to the possibility of selecting a voltage system higher than the existing 4000/2300, and several were selected for comparative study.

4000/2300 Volts Star—Four-Wire. This system is well-known in America as the best method of caring for increased load on a 2300-volt delta system without large expenditure for new equipment.

4000 Volts—Three-wire. On a rural line there is little secondary bus so that the saving by the use of a common neutral is negligible. On the other hand, by using 4000-volt transformers, the neutral conductor can be omitted at a considerable saving, both in first cost and also in the loading of the poles. This saving balances the cost of a second cut-out and arrester for each transformer. The greatest advantage of this voltage, however, is the ability to use 4000 instead of 2300 volts for single-phase branches, with a resultant saving

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in copper; especially where it is possible to use single- instead of three-phase.

6600 Volts Delta and 11,200/6600 Volts Star. For rural lines, 6600 volts is frequently used together with its star connection, 11,200/6600 volts. The latter requires higher line insulation than for 2300 volts and when building a 6600-volt line, it is advisable to prepare for a possible future change to the higher star voltage. Transformers and protective equipment for this voltage are considerably higher than for the lower voltages.

6920/4000 Volts Star. This system has the advantages of a higher voltage than the 4000/2300-volt system and uses similar equipment to the 8000/4600-volt system, although with greater line losses than the latter.

8000/4600 Volts Star. Transformers with series parallel windings of 4600/2300 volts tapped for 4000 and 2000 may be obtained at cost about 10 per cent in excess of that for 2300 volts. Also, these transformers are subjected to a 17,000-volt test instead of the 10,000 volts used for the 2300-volt transformer. This transformer is exceptionally suited for rural work in that it may be used on the following voltages; 2300 volts delta, 4000/2300 volts four-wire, 4000 volts three-wire, using the 4000-volt tap, 4600 volts three-wire, and 8000/4600 volts four-wire.

One open type fuse switch and one arrester is used for each transformer. The same line is used as for 4000 or 2300 volts as the same insulation and clearances are satisfactory.

This transformer is suitable for use on practically any rural line in the province having the same frequency which eliminates the carrying of a large stock of spare equipment.

When it is not possible to change a whole substation to 8000/4600 volts, it is possible to obtain this voltage by the use of a bank of 4000/4600 volts transformers connected delta on the 4000 volts system, and star on the 8000-volt side. The delta-star connection is preferable to the star-star, in that circulating third harmonics are eliminated, greatly reducing any inductive interference that may appear on neighboring telephone lines.

26,000 Volts Delta. A system of this voltage is usually not suitable for rural work due to its high cost, both for the original line and for its maintenance.

Transformers for this voltage are relatively expensive and usually not made in sizes of less than 10 kv-a. A set of arresters costs nearly as much as the transformer, and a fuse renewal costs very many times that of one for the lower voltage.

A great hazard on rural lines is trees, and with this voltage, they must either be overbuilt or removed.

After consideration of all of the above points, it was decided to adopt the 8000/4600-volt system wherever a higher voltage was required for rural.

Since 1926 about 400 mi. of line of this voltage have been placed in operation, some of it being new line, and the balance old lines changed over from 4000 volts. The maintenance on these lines has not been any greater than on those of the lower voltage. The inability to work on live lines at this voltage does not enter into the question at present, as work is not permitted on live lines of rural systems of 2300 volts or over.

Also, many of the lines are now built at 4000 volts three-wire and two-wire.

Economical Span

Much has been written on the subject of an economical span but it is not possible to lay down a hard and fast rule for the whole country as there are a number of local controlling factors, such as labor costs, material costs especially as regards poles, and also the nature of the surrounding terrain.

When it was first realized that the construction of rural lines would be a large proposition the prevailing urban span of 125 ft. with No. 6 weather-proofed copper wire was lengthened to 160 ft. and hard drawn bare copper was erected. Poles were 30 ft. with six-inch tops.

Lines of various span were designed and estimates prepared and the results plotted as shown. Abrupt changes in the curves are due to changes in size of poles, as tops come in diameters of 6, 7, and 8 in. and changes in length of 5 ft.

Loading was based on ½-inch of ice with 8 lb. of wind.

A great many miles of line were built using the 250-ft. span with 30-ft. 7-in. top poles and steel reinforced aluminum. This line will withstand the load mentioned above, whereas the previous 160-ft. span with No. 6 hard drawn copper was designed for ½-in. ice and 4-lbs. of wind. The latter is too long a span for a copper secondary bus, and too short for the use of interspaced poles, whereas 250 ft. lends itself very readily to the use of an intermediate pole to give a span of 125 ft.

Recently, due to the large quantity of 6-in. top poles produced it was decided to build a large proportion of the lines with 200-ft. span instead of 250-ft. At the same time, the 160-ft. spacing was replaced with 150-ft. to allow for greater wind loading, although severe sleet storms or excessive winds are rare in Ontario.

Construction Details

Following is a review of the standard specifications for the stipulated types of rural construction:

200-ft. span; 150-ft. span; 250-ft. span with triangular framing secondary; and underground.

200-ft. Span. Poles are 30-ft. eastern cedar with 6- or 7-in. top without any preservative treatment.

The spacing of 200 ft. is maintained as far as possible, but it is frequently necessary to shorten the span in order to avoid a driveway, or to locate a pole in a suitable position for taking off a service. Where a secondary bus is to be erected at once the span is cut to 125 ft. At angles of 30 to 60 deg., the adjacent spans

are shortened, but at all other angles the full span is permitted.

The crossarm is 3¾-in. by 4¾-in. untreated fir, with a pin spacing of 30 in. The arm is bored for half-inch steel pins, but only the pins immediately required are installed.

On tangents, a one-half-inch steel pin with lead thread is used, with the end of the bolt lightly riveted after installation. The steel pin does not tend to split the arm as does the wood pin and does not deteriorate rapidly. At angles up to 45 deg., a single arm with clamp pin is erected; and from 45 to 60 deg., the crossarms are double. At greater angles buckarms with clevis are erected. All conductors are dead-ended on a clevis.

Conductors are No. 4 or No. 2 steel reinforced aluminum cable.

On straight runs, the conductor after being protected with a layer of aluminum tape, is tied in the top groove of the insulator.

The standard long aluminum tie is used with about 40 in. of tie wire.

The conductor is spliced with two twisted aluminum sleeves with four turns each. At dead ends, the conductor is passed through a single sleeve, around the clevis insulator and back through the sleeve, the sleeve being given four full turns. A layer of armor tape is applied to the conductor where it is in contact with the insulator.

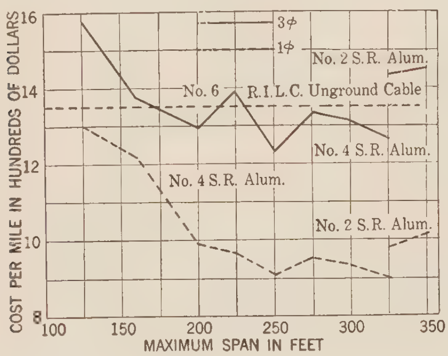

Fig. 5—Economical Span

For clamping aluminum at taps, a two-bolt aluminum clamp is used; for clamping to copper at transformer taps, a one-bolt copper-bushed universal clamp is installed.

At the feeding point, at tap lines, and at least every five miles, fuse switches are installed. An open type switch is used and the conductor is broken with a clevis, using a single arm.

For permanent single-phase lines, crossarms are two-pin with 30-in. pin spacing.

150-ft. Span. This construction is similar to the 200-ft. span line. Crossarms are 4-pin with 18-in. pin spacing except the pole pins which are 30 in. apart. Conductors are either steel reinforced aluminum or hard drawn copper. If the latter, a side tie insulator is used due to its lower cost. The copper is spliced with a single sleeve and is deadened in a similar manner to the aluminum except that a half sleeve is used.

Triangular Construction. A new form of construction is being tried out with very satisfactory results, using steel reinforced aluminum cable.

With a span of 250 ft. and 7-in. top poles, a two-pin 30-in. spacing arm is erected for single-phase ungrounded line. For three-phase four-wire circuit a 3-ft. top pin is added on the back of the pole using the crossarm through bolt and an extra bolt below. The neutral is carried on a bracket bolted to the pole about two feet below the arm giving a symmetrical configuration. For single-phase grounded line, only the top pin and neutral bracket are required.


Fig. 7—Line Sectionalizing Switches—Open Type


Fig. 9—Triangular Construction—Angle

Secondary. Usually the 115/230-volt secondary is erected on racks and brackets, with a spacing of 6½ in. The bare copper neutral is placed in the top position with the weather-proof outers below. If there

is a multiple street lighting control it is placed below the house lighting secondaries. Side tie glass insulators are used.

Recently, some bare secondary of hard drawn copper was erected on brackets with a vertical spacing of 12 in. This appears to be an economical form of construction both for first cost and for maintenance. The conductors are erected with less sag, and the load due to sleet and wind is far less.

For taps, soldering has been eliminated by the use of clamps. The tap conductor is first given three turns around the line wire, and the clamp applied to the tail end.

The minimum size of transformer purchased is 3-kv-a. and a large proportion of them is of the 4600-volt type with secondary of 115/230 volts.

Fig. 10—Transformer Mounting 2300 Volts

Each transformer is protected with one cut-out and one arrester if on a grounded line. Otherwise two of each are used. For 4000 volts or less, a wet process dorcelain cut-out is installed. For 4600 volts an open type fuse switch is mounted on the line arm so that when the fuse is pulled with a stick, everything below the line arm is dead.

Underground. In 1922 the Commission commenced the installation of underground rural cable, and to date there are some 150 mi. in service.

This underground cable is used with the 4000/2300-volt system using a single-conductor cable with the lead sheath for the return circuit. For three-phase, three cables are installed in the same trench, separated by a few inches.

Most of the cable installed was rubber and lead, but lately a paper-insulated cable has been used as being of a more uniform quality. However, the rubber has the advantage of allowing the cable to operate with a defective sheath for a long period of time without trouble due to moisture.

For the installation, an 18-in. trench is dug with a plow or a road scraper, and shovels, and the cable is dropped in and back-filled with the scraper, without a cover board.

At a consumer the cables from both directions are brought up a pole to disconnecting potheads, and the transformer is tapped to the jumper between the potheads on the one side, and to the lead sheath on the other side.

This underground system has been very satisfactory, especially where heavy trees or foreign lines were encountered. At the time of installation, there was a considerable saving in cost as against the overhead for single-phase. However, the cost of cable rose considerably, and at the same time due to more economical forms of construction, the cost of overhead lines was reduced by about 20 per cent.

Also a three-phase underground line costs nearly three times as much as a single-phase line, whereas with an overhead line, due to a large proportion of the cost being in the supports the change to three-phase is not expensive.

Conclusions

A voltage system must be selected which will provide for future loads without undue financial burden for the present.

The question of span length is of great importance and should be given consideration with regard to first cost as well as operation.

Standards of construction should be of a high order, particularly as the cost of maintenance on a rural system is necessarily high.

In many sections the problem of tree clearances is just as acute as in municipalities.

The advantage of steel pins over wooden ones justifies the additional expenditure.

The dead-ending of all conductors on clevises instead of on pins is a great advantage. Especially in the smaller sizes there is a big advantage in the use of steel reinforced aluminum cable as compared to copper as it permits the use of a longer span and also has greater strength to resist accidental loads such as trees and sleet.

There is a considerable saving in labor by the use of clamps instead of soldering. It is recommended that the conductors be served and the clamp applied to the tail end.

The use of bare secondary is recommended for racks with a spacing of 12 in. on the pole.

In locations where trees or other obstructions exist, underground cable may be economically installed for single-phase loads.

Abridgment of

The 220,000-Volt System
of the Hydo-Electric Power Commission of Ontario

BY E. T. J. BRANDON*

Fellow, A. I. E. E.

Synopsis.—*Power requirements of the Commission's 25-cycle Niagara System are outlined. Preliminary studies in connection with the choice of transmission voltage, location of terminal transformer station, etc., are discussed, together with the technical studies involved in the design of a system for transmitting 260,000 hp. 230 miles at 220,000-volts, and transforming same at the receiving end, for interconnection with the existing 110,000-volt system.*

The Toronto-Leaside 220,000-volt transformer station is described, together with the 220,000-volt transmission system.

The paper concludes with a resumé of operating experience on the 220,000-volt system to date, and an outline of the future development of the system as at present anticipated.

Introduction

THE Niagara System of the Hydro-Electric Power Commission of Ontario covers an area of some 1200 sq. mi. in the southwesterly portion of the Province, adjacent to the shores of Lakes Ontario and Erie.

With the exception of several large electro-chemical customers located in the vicinity of the Niagara River, the power demand on this system comes from some 371 municipalities, ranging in size from the City of Toronto to the small villages.

Previous to October 1928, this municipal load was supplied from the Commission's generating stations located on the Niagara River, but, commencing in that month, power to supply the increasing demand was purchased under contract. A block of 260,000 hp. was purchased from the Gatineau Power Company, supplied from the Gatineau River in the Province of Quebec, some 230 mi. to the east of Toronto, and transmitted over the Commission's transmission lines from the interprovincial boundary, for interconnection with the Niagara System.

History of System Growth

The annual increment of the peak load on the Niagara System is of the order of 75,000 kw., while that of the metropolitan area of Toronto is of the order of 25,000 kw.

Referring to Fig. 2; the original station of the Commission in Toronto is marked as Strachan T. S. York T. S. was constructed west of the city in 1918, while the two stations marked as Wiltshire and Bridgman were constructed in 1924. At this time, the three city stations were spaced almost equally around the center of gravity of the load, and at three-mile centers.

By 1926, the demand of the eastern area pointed to the necessity of a fifth 110,000-volt transformer station.

At this time the contract with the Gatineau Power Company was entered into, and Toronto was chosen as the point at which the necessary interconnection would be made. The problem of additional transformer stations became merged, therefore, with the problem of devising a plan whereby this new source would be incorporated with the existing system.

Load Analysis and Location of Station

As a result of economic studies a nominal transmission voltage of 220,000 volts was adopted. Based on this decision a tentative system layout was devised. The 220,000-volt station was located north and east of the city limits, where it was proposed to step-down to 110,000 volts, transmitting into the city at this voltage.

Alternative sites for 110,000-volt transformer stations were selected, and economic dividing lines between these sites and existing stations were drawn, the object being to plan a 110,000-volt distribution system.

These studies brought out the possibility of locating

Fig. 2—Toronto and Vicinity, Showing High-Voltage Transmission Lines and Stations. December 1929

the 220,000-volt station so as to supply 13,200-volt power directly, utilizing the delta-tertiary windings. The increase in the cost of transformers would be relatively small, which would allow practically the whole of the cost of the second transformation, from 110,000 volts, to be utilized to extend the limits of 13,200-volt distribution from the station, thereby fully loading the station at this voltage within a few years.

It will be noticed in Fig. 2 that the valley of the Don River cuts through the city from the northeast. It was found possible to extend the 220,000-volt system through this territory, from the original tentative location of the station into an urban location such as would allow of the above plan. The studies were completed with the selection of the present site.

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System Studies

The arrangement of transformer windings, (*i. e.*, three windings, 220,000-, 110,000-, and 13,200-volt, each of full capacity,) practically decided the size of the transformers as being the largest that could be transported in a built-up condition between the manufacturer's plants and the transformer station. Four banks of three 15,000-kv-a., single-phase, oil-insulated, water-cooled units were decided upon.

The condenser capacity required to maintain satisfactory receiving-end voltage regulation was calculated as 100,000 kv-a. These condensers will operate to maintain the distribution voltage within the required limits, under-load tap-changing being provided on the 110,000-volt windings to control the exchange of wattless current between the interconnected systems.

It was felt that the design of this system should be such as to promote stability of operation. To this end,

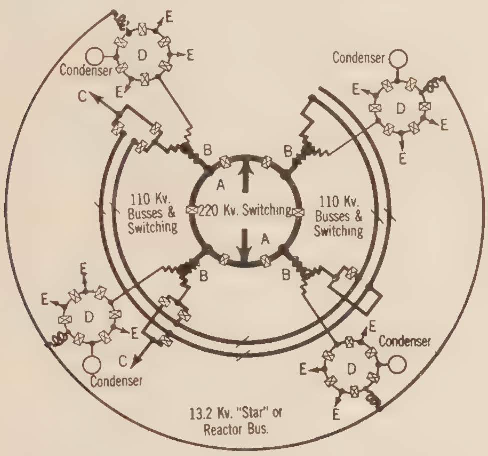

Fig. 6—Schematic Circle Diagram—Main Switching. Toronto-Leaside Transformer Station

A. 220-Kv. incoming lines
B. Three-winding transformers 220/110/13.2 kv.—45,000 kv-a. each winding
C. 110-Kv. outgoing feeders
D. 13.2-Kv. ring bus
E. 13.2-Kv. outgoing feeders

the highest speed of clearance then obtainable in 220-kv. circuit breakers was specified, and the relay system designed to operate to clear faults instantaneously.

Quick response excitation systems were installed on the generators of the Gatineau Power Company, and on the synchronous condensers at Leaside. In the former case, motor-generator exciter sets driven from service generators direct connected to the main units were used, separately excited from pilot-exciters. In the latter case, direct-connected main exciters were used, separately excited from pilot exciters also direct-connected.

Features of the Toronto Leaside 220,000-Volt Transformer Station

The ultimate station arrangement at Leaside provides for eight banks of transformers (360,000 kv-a.) and four 220,000-volt lines. The initial installation required for the Gatineau contract power consists of four banks and two lines, which installation will be completed by the fall of the present year. The station diagram for this initial installation is shown in Fig. 6.

The four banks of transformers of the initial installation consist of three 15,000-kv-a., single-phase, 25-cycle, 118,000-, 65,000-, and 13,200-volt, oil-insulated, water-cooled, three-winding, outdoor units.

The tanks, made in three sections, were shipped to the station unassembled. The main core was completely assembled in the factory and shipped in oil in special shipping tanks. Complete assembly of the transformer was made in the service building.

The 220,000-volt oil circuit breakers have a current rating of 800 amperes, and a rated rupturing capacity of 2,500,000-kv-a. They are equipped with oil-filled bushings, rated for operation at 127 kv. to ground, though provision has been made for bushings of a size suitable for a 220-kv. isolated neutral system.

All the 220-kv. disconnecting switches are upright, mounted on pillar insulators. When used as isolating switches on an oil breaker the two sets of switches operate together from one control, electrical interlocks being provided to prevent their being operated under load.

The 220-kv. leads are constructed at three elevations. The lowest conductors are twenty feet above ground and consist of 2-in. copper tubing supported on post insulators. The upper two tiers are suspension-equipped, spaced to give 20 ft. minimum clearance between tiers.

The 110,000-volt oil circuit breakers are rated at 135 kv., 600 ampere, with a rated rupturing capacity of 1,500,000 kv-a. They are equipped with condenser bushings and solenoid-operated mechanisms.

The disconnecting switches are of the swivel type, with three stacks of insulators, the center one rotating.

For the first two banks of transformers the complete 13-kv. switching equipment is located indoors, the oil breakers, disconnecting switches, reactors, etc., being housed in separate compartments.

The switching for the second two banks is of the outdoor, isolated-phase, metal-clad type.[1] The delta-bus is formed on steel structures immediately behind the transformers, similar to the first two banks, from which cable is run to the separate phase structures.

The synchronous condensers installed at Leaside[2] are vertical-shaft, outdoor units. (Fig. 10) They have a combined spherical thrust and guide bearing located below the rotor, with a direct-connected main and pilot exciters located below the thrust bearing. They are rated at 25,000 kv-a., 500 rev. per min. One is connected to each bank of transformers.

To dismantle these units, the exciters are discon-

1. *Metal-clad, Gum-filled Switchgear*, by L. B. Chubbuck, A. I. E. E Summer Convention 1930.

2. *The 25,000-kv-a. Vertical Shaft Synchronous Condensers for the Toronto Leaside Transformer Station*, by R. E. Day, H. A. Ricker, and J. R. Dunbar, A. I. E. E. Summer Convention 1930.

nected immediately below the bearing, and moved from under the machine. Removal of a small cover allows the crane (80-ton capacity gantry) to take the weight of the rotor. Certain blocking is removed, and the rotor with its bearing is dropped down into the foundation. The cover replaced, the unit is again weather-tight and the armature and field windings are completely accessible.

To minimize coil creepage, a constant machine temperature is maintained by automatic dampers controlling the air circulation.

Lightning Protection

The problem of providing what would appear to be adequate lightning protection for the 220,000-volt station was given considerable study. The decision

Fig. 10—25,000-Kv-a. Synchronous Condenser. Toronto-Leaside Transformer Station

A 25,000 Kv-a. condenser, 500-rev. per min., three-phase, 25-cycle, 13,200 volts
B 80-Ton gantry crane
C 150-Kw., 125 volt main exciter
D 30-Kw., 250-volt pilot exciter
E 9000 Kv-a. auto transformer
F Main incoming air damper
G Main outgoing air damper
H Recirculating air damper
I Damper for basement heating
J Spherical seat thrust bearing
K Upper guide bearing
L High-pressure oil pump for starting
M Starting structure and equipment
N Truck for handling exciters
O Threaded hole for rotor lifting eye
P Air filters
Q Current transformers

was made initially to omit arresters, but to coordinate the transmission line and station insulation.[3]

In the interval, the characteristics and protective value of arresters have been more clearly defined, and a special design of 220,000-volt, valve type arrester is now being installed. Normally eighteen units are in service, with four additional units short-circuited by a disconnecting switch, which is opened automatically if the dynamic voltage exceeds a predetermined value.

Relaying and Control

For relay purposes, the system is divided into elements, each bounded by automatic oil circuit breakers. The elements are of two classes; those entirely within the station, known as "zones," and those which extend from the station, *i. e.*, lines and feeders.

3. *Coordination of Insulation as a Design Problem*, by G. D. Floyd, A. I. E. E. Summer Convention 1930.

The station zones are each covered by simple current-differential instantaneous protection, set below normal load current. The transformer banks have an inverse time feature, to take care of incipient faults, and to avoid tripping on magnetizing current when energizing.

Long lines and feeders are equipped with directional double-distance-range impedance relays, for phase- to phase faults and ground faults.

For standby protection on phase faults, a set of long-range distance relays are supplied on each transformer bank, timed beyond the instantaneous features. For grounds, residual current, or voltage relays are used, timed in the same way.

For 220-kv. potentials, 13,200-volt potential transformers, with transformer drop compensators, have been used.

Miniature control has been adopted at Leaside. Standard telephone keys mounted on the top of desks about the size of ordinary office desks are used. On one desk is mounted the control for one 220,000-volt transmission line and two transformer banks with attendant equipment—one-quarter of the ultimate station. Other standard telephone equipment operated at 48 volts is used throughout the remainder of the control.

Features of the 220,000-Volt Transmission System

The 220,000-volt transmission system constructed by the Commision to deliver the Gatineau contract power to the Niagara System extends from near Chats Falls on the Ottawa River (the interprovincial boundary between the provinces of Ontario and Quebec) in an almost direct line to Toronto. Although this route involves about 100 mi. of extremely rough country, it was decided to be more economical than a longer but more accessible route.

Because of this inaccessibility and the lack of detailed maps of certain sections, aerophotography was resorted to in surveying the route for these lines. Oblique photographs were used for preliminary location, after which, vertical photographs were taken over the selected center-line. These verticals were used under the stereoscope for office location of actual tower sites. Mosaics, on which were marked the selected center line and tower sites, were supplied to field survey parties.

Transmission line rights were secured on a 40-year easement basis, except for a distance of about 10 mi. east from Toronto, where a 450-ft. strip is being purchased. The aerial pictures were found to be of great assistance in arranging for right-of-way and for clearing rights.

Structural Design

The standard suspension tower adopted for these lines is shown in Fig. 13. Towers are designed for a maximum conductor tension of 10,000 lb., and for Class *B* loading along the line, and Class *C* loading across the line. They are of part silicon construction,

the standard suspension tower with footing weighing 10,400 lb.

Light-angle, semi-anchor and transposition towers are also provided. The light-angle tower takes care of long spans and for angles up to 4 deg., while the semi-anchor allows for dead-ending and for angles up to 45 deg. These towers weigh 11,000 and 15,900 lb., respectively.

Transpositions are of the rolling type, involving two towers, there being 33 transpositions in 203 mi.

Footings in earth are of the grillage type. Rock footings consist of two channel members bolted down with rock-bolts. The stub-angle on footings provides an adjustable telescopic joint, by means of which minor variations of elevation may be compensated for.

The standard span adopted for these lines is 1056 ft. There are actually nearly 1000 towers per line in 203 mi., an average span of approximately 1080 ft.

As a result of tests carried out with the cooperation of

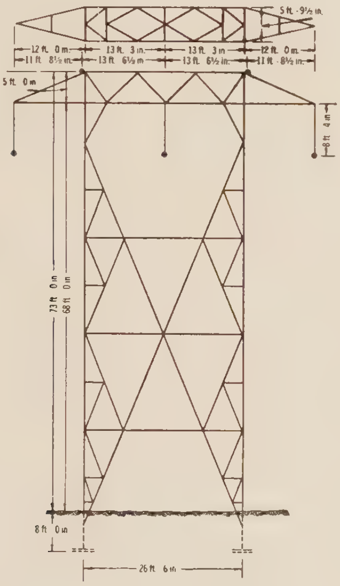

Fig. 13—Outline Standard Single-Circuit Suspension Tower

manufacturers, and after study of results of other investigations, it was decided to install eighteen 5-in. spacing suspension units in all suspension positions without grading rings or arcing horns. Provision has been made in the clamps to add rings if later found desirable.

Power conductors are 795,000-cir. mil, steel-reinforced aluminum cable, 27.2 per cent steel, strung to a maximum tension of 10,000 lb.; maximum sag 36 ft. Ground cables, of which there are two, are of the same construction as the steel core of the power cable. Cable clamps on both cables are designed to allow three-way movement at the point of support, in order to mitigate vibration troubles. Vibration dampers are also provided.

Special Terminal Section

For approximately 2 mi. within the vicinity of the terminal station, the structure height has been reduced 13 ft., and the span reduced to one-half. Fourteen, instead of eighteen insulator units, and four, instead of two ground cables are installed, this in accordance with the attempt made to coordinate the line and station insulation.

Construction

Construction of the first 220-kv. circuit commenced in July 1927, and was completed and placed into operation on October 1, 1928. Construction of the second circuit was commenced in May 1929, and approximately one-half was completed by October 1929. This half-circuit has been in operation since that time, connected directly in parallel with the first circuit. The whole circuit is scheduled for completion in July 1930.

Line erection was carried out in three stages: Footing-gangs first placed the footings, templates being used in setting and leveling. Tower erection gangs followed carrying out the actual tower assembly. Towers were assembled in panels on the ground and lifted into place by means of a 30-ft. gin pole suspended within the tower frame. Stringing was carried out by the third gang. Insulators were hung and pulleys attached in the clamp position. Conductors were paid out through the sheaves, jointed to form about a 5-mi. section which was sagged in to final tension at one time.

In general, the two circuits have been constructed with a spacing between circuits of 150 ft., this being considered sufficient to avoid simultaneous damage to both circuits, while retaining the benefits of a single patrol staff and paralleling telephone.

Operation

Between October 1, 1928 and April 1, 1930, ten line outages have occurred on the 220-kv. system, four of these attributed to lightning and the remainder to miscellaneous causes, largely a product of the period of adjustment which all new systems suffer. In all cases but one, the line has returned to service immediately. Of the lightning flashovers, relay indications point to two being single-wire grounds, one a two-wire ground, and one a three-wire ground with very little ground-fault current, though in no case has the point of flashover ever been located.

Active construction is soon to start on a third 220,000-volt circuit, approximately paralleling the first two, bringing power to Toronto from the Chats Falls development on the Ottawa River, while preliminary work is being carried on 220,000-volt circuits from the Beauharnois development on the St. Lawrence River, and also on a second 220,000-volt transformer station in the Toronto area. Within five or six years it is expected that approximately 1400 circuit mi. of 220,000-volt lines, and two transformer stations of a combined capacity of 540,000 kv-a., will be in operation.

Acknowledgments

The author wishes to express his appreciation of the valuable assistance given by Messrs. A. H. Hull, A. E. Davison, and A. H. Frampton in the preparation of this paper.

Abridgment of

Directional Ground Relays

BY E. E. GEORGE[1] Member, A. I. E. E. and R. H. BENNETT, Jr.[2] Associate, A. I. E. E.

LESS than four years ago there appeared the following summary of protective relay practise for transmission systems:

"Electrical faults on a transmission or distribution system consist mainly of short circuits and grounds. The protective scheme is primarily designed to operate on values of current caused by short circuits between phases. . . . . If the neutral of the system is grounded, the method of grounding has an important bearing on the protective scheme. Where the neutral system is dead grounded, or grounded by means of a low resistance, the protective scheme designed to operate on short circuit usually also protects against grounds."

The above quotation will be recognized by many as taken from the *Relay Handbook* which was prepared by a joint committee of the N. E. L. A. and A. I. E. E., and undoubtedly represented the latest thoughts as of 1926.

Late in December 1929, the *Electrical World* in reporting the World Engineering Congress at Tokyo, made the following statements:

"During the past 5½ years of 220-kv. operation on one system, there have been 148 cases of trouble, and in all cases, a flow of ground current was recorded. Even though the trouble resulted from widely varying causes, such as birds, fires, floods, lightning, sleet, contact with telephone wires and contact with trees, etc., ground current is always indicated. Accordingly, on one system, the decision has been made to relay for protection solely upon residual or ground current relays. . . . . Phase relays are retained on most systems, but many engineers are agreed that phase to ground protection is the most essential for 220-kv. operation."

The industry has come to accept grounded neutral operation as economically advantageous and technically indispensable. Fundamentally, neutral grounding operates to facilitate protection by providing at the switching station a circuit for fault current independent of the load current. Overload protection utilizes common circuits for fault and load currents and can distinguish fault current from load current only when the fault current is large compared with the load current. The efficiency of ground relay protection which has resulted in its popularity of late years is largely due to the following factors:

Advantages of Ground Relays:

A. Ground relays are independent for all practical purposes, of surges due to switching, synchronizing, motor starting, condenser starting, etc.

B. Ground protection is based on the fact that the current flowing in the relay under normal conditions is zero, and therefore such protection is even more sensitive than differential or balanced protection with phase relays.

C. Ground relays can easily be made to operate at higher speeds. Directional ground relays now operate on some systems as fast as five cycles, and one type of special induction relay used for initiating the operation of oscillographic equipment operates in two cycles.

D. The high attenuation of ground fault current with distance results in automatic selectivity. The zero sequence impedance of lines is usually considered to be three and one-half to four times the positive sequence impedance, which means that distance provides several times as much discrimination on ground faults as it does on phase faults.

E. Ground relays are applicable to systems either solidly grounded or grounded through impedance, although they are applied more easily and more satisfactorily to solidly grounded systems.

F. Ground relays are applicable to multi-grounded systems. With the increasing number of interconnections, such systems will soon result, even though we started out originally with each system grounded at one central point.

G. Ground relays are applicable to networks and to inter-company tie lines because they are independent of the location of generation, and thereby afford dispatchers maximum freedom in allocating power supply. Relay schemes should avoid unnecessary restrictions on the location and amount of generation, and ground relaying does this much more thoroughly than any available form of phase protection.

H. Ground currents can now be calculated with sufficient precision to enable ground relays to be set correctly.

I. Equipment is now available to check ground current and the tripping time of ground relays under actual fault operation on the power system.

J. Ground relays operate fast enough to clear up faults with a minimum amount of damage to insulators, bushings, and windings. Most high-voltage line failures can be cleared quickly enough by ground relays to prevent burning the line down, except in cases of direct lightning strokes.

K. Ground relays usually clear up lightning flash-

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overs, wires swinging into trees or structures, etc., before the arc has time to spread into adjacent phases.

L. Ground relays prevent lines down on the ground from remaining energized and endangering lives and property.

M. In order not to limit the economic capacity of the circuit phase protection has to be proportional to the maximum carrying capacity of the largest section of a circuit. Small branches connected to heavy circuits cannot be protected by such maximum settings of phase relays, but ground relays may be set low enough to protect small transformers or small conductors.

N. It is very frequently difficult or impossible to install differential protection on transformers or rotating equipment, but in practically all such cases, ground relays can be used to give satisfactory protection, especially if the transformer or generator windings are not grounded.

O. In general, systems of different voltage will not interchange ground current except when coupled by auto-transformers or by three-winding transformers with two grounded *Y* windings. It is possible, therefore, to set ground relays on one voltage system independently of those on another voltage system.

Advantages of Directional Ground Relays:

A. Directional ground relays do not necessarily require potential connections.

B. Directional ground relays may be made independent of fault power factor for all practical purposes.

C. The direction of normal power flow and reactive flow have no effect on directional ground relays.

D. It is unnecessary to interlock phase and ground relays when directional ground relays are used.

E. Directional ground relays have more highly inverse characteristics than any other type of relay. Their characteristic curves are almost rectangular hyperbolas, which are, of course, the theoretically perfect form of inverse characteristic.

Disadvantages of Ground Relays:

Any discussion of the merits of plain ground relays and directional ground relays would not be complete without reference to the objections raised against such relays by those who are not using them.

A. "Ground relays often operate too fast and trip out a line on remote trouble."

This is entirely a matter of setting. Many systems operate with less than 1 per cent of incorrect operations due to such causes. Ground relays with low-current taps and fast time settings cannot be used indiscriminately on networks any more than could phase relays with similar current and time settings. However, on radial feeders it is often possible to use ground relay settings of 5 per cent to 15 per cent of the phase settings and considerably shorter time. The increased zone of protection is readily apparent.

B. "Ground currents are difficult to calculate." This has been substantially true until within the last year or two. Recently much progress has been made. Several companies use d-c. calculating tables to determine ground currents. Long hand calculation can be used without special difficulty by making use of several assumptions justified by field test during the last year and described in the serial report of the Southeastern Division, Electrical Apparatus Committee entitled, "Calculation of Ground Currents."

C. "Ground currents are difficult to measure." This is no more true of ground fault current than of phase fault current. Any comment on either should take note of recent developments and improvements in high speed graphic ammeters and the oscillographic equipment.

D. "Ground relays are unnecessary if a system is grounded at every supply transformer, as every ground fault will take enough current to operate phase relays."

This may be true on short lines and at the lower voltages, but it is well known that even phase fault

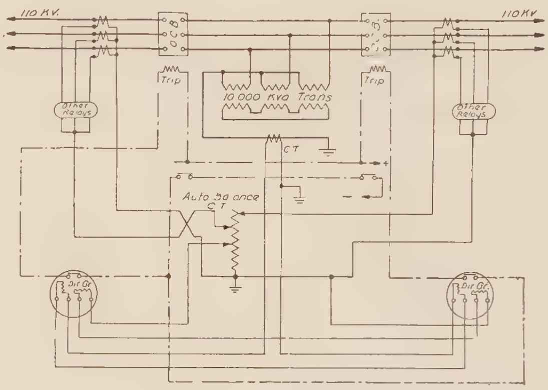

Fig. 4—Directional Ground Protection on Loops

currents at higher voltages may be less than maximum load currents, in which case, phase protection of any ordinary overload or reverse power type is unreliable and hazardous.

A few of the most valuable ground relay applications are given below.

Directional Ground Protection of Loops

Fig. 4 shows the scheme of directional ground protection used on a 110-kv. loop. The fundamental feature of this scheme is the cross-connection. This is shown here as completed through an auxiliary current transformer, but it is required only on unsymmetrical loops. On symmetrical loops and on parallel lines the auto current transformer may be omitted, since equal primary currents in the same direction in each line will neutralize each other in the secondary circuit. When the auto current transformer is required, it should be connected so that both secondary currents will neutralize each other on trouble on the far end bus,

and thus prevent tripping either line. The ground current supplied by the home and grounding transformer is used chiefly for directional discrimination and not for time selectivity, therefore, a small grounding bank can be used if necessary, particularly at the receiving end of the loop.

The standard wiring scheme for Fig. 4 is as follows: The secondary of the neutral current transformers goes through the upper elements of two directional ground relays in series. The lower elements of both relays are in series and are connected to the bushing current transformer secondary neutrals in multiple. These bushing current transformers and relays have symmetrical polarity but are reversed at the common or multiple connections so that the lower elements of the relays received the difference of the residual line currents when ground current is going out of both lines. When ground current is feeding through, the residual currents in both lines add in the relay circuit. The characteristics of this connection are as follows:

With both lines in service and either line in trouble,

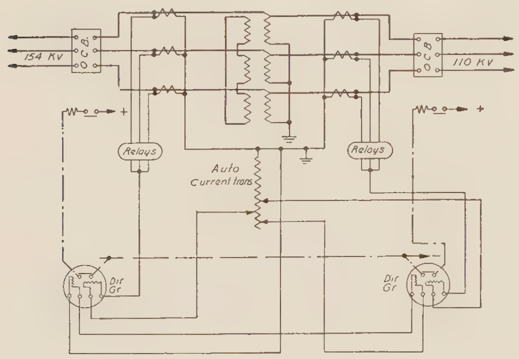

Fig. 5—Directional Ground Protection on Auto-Transformer Ties

and the loop open at the far end, the bad line trips correctly and very quickly. With both lines in service and the loop closed at the far end, the line carrying the heaviest fault current trips correctly but very slowly, giving opportunity for the other end to clear and relieve the fault current on the good line. If both lines are in service and in trouble and the fault current is balanced, neither switch will operate. If the home bus is in trouble and the line fault currents are balanced, neither switch will trip. If the home bus is in trouble and the line fault currents are unbalanced, the line carrying the smallest current will trip slowly. The other line will not trip. With only one line in service and in trouble, this line will relay satisfactorily unless the trip circuits are interlocked. If trouble occurs on the bus, with only one line in service, this line will not trip at that end.

Except on symmetrical loop circuits, this connection will not operate correctly if there are other lines off of the bus at the home unless some means is provided for making both lines directional. This can be done by standard directional ground relays used as locking relays on the trip circuits.

This scheme may require series auxiliary switches or locking relays operated by trip current if used on a loop of three or more links, so as to prevent the second line tripping too quickly after the first. However, series *A* switches are not desirable at the power supply end of a loop, as they do not give single-line protection except on backup relays. For such installations, locking relays are better as they will restore directional ground protection on the second line in a few seconds. If one end of the balanced lines is without power supply, protection on the second line for single-line operation is usually immaterial.

Directional Ground Protection on Auto-Transformer Ties

Fig. 5 shows an application of directional ground relays to auto-transformer stations or other stations, where the grounding transformer neutral is not brought out but is grounded inside the transformer case. In general, this scheme is applicable only to stations with only two transmission lines. It is particularly suitable for auto-transformers with high reactance tertiary windings and wide difference between high and intermediate voltages, especially if the intermediate voltage ties closely into a heavily grounded system.

In case of a fault on the high-voltage side, such an installation may result in zero or reversed ground current in the auto-transformer neutral, due to the large amount of ground current put out by the intermediate voltage system. The neutral current is, therefore, not suitable for directional discrimination and some other references current must be obtained. Delta current is difficult to get, especially if the auto-transformer is used to supply a load from the delta winding.

The scheme of connections shown in Fig. 5 provides excellent bus protection. No neutral current transformer is required. The scheme is applicable to auto-transformers regardless of ratio. It is very similar in operation to the balanced ground relay scheme for auto-transformers. The line bushing current transformers are connected with symmetrical polarity and are connected symmetrically to the lower elements of their respective directional ground relays. The bushing current transformer neutral circuits are then connected totalizing so that the upper coil would receive the sum of the line currents if both lines were feeding out. On through feed, the upper coil receives the difference of the line currents, which is the ground current put out by the station. In case of auto-transformers, it is necessary to install an auto current transformer in one current transformer secondary before the multiple connection is made.

This auto current transformer can be set in the ratio of voltage transformation of the power transformer so as to cancel out the through ground current.

This scheme operates well with either line in trouble. It also gives perfect bus protection with one or both lines in service, whether they are balanced or not. This is a disadvantage on loop circuits, and therefore it should not be used in place of balanced relays on a loop or parallel lines, but it is satisfactory where the outgoing circuits are not connected together at any other point for any appreciable interchange of ground current. The scheme will naturally not operate if there is no supply of fault current at the station, but it will operate with one line out of service and will trip on either bus or line trouble. The relays work rapidly when current is going in the same direction in the two lines and as fast as ordinary directional ground relays connected in the ordinary manner using a current transformer in the power transformer neutral.

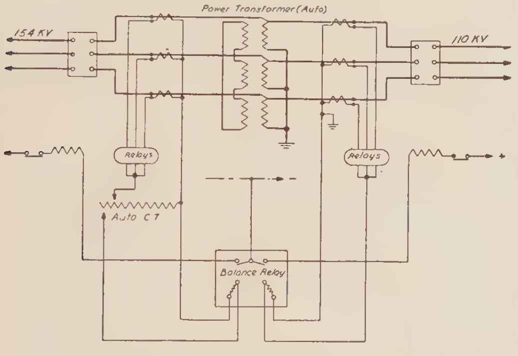

Fig. 6—Balanced Ground Protection

If trouble occurs on the bus the current is in the opposite direction to that provided by a neutral current transformer, resulting in rapid bus protection.

This scheme is particularly useful where the power transformer neutral is not brought out, where a proper ratio neutral current transformer cannot be obtained, or where the direction of current in the neutral is indeterminate. In the last case, it has the same advantage of using circulating current in the delta for polarizing directional relays, but is independent of the delta load current. Since the line current transformers are usually of considerably lower ratio than neutral current transformers, it provides much more current for the directional ground relays and may require special relays to get settings sufficiently high.

Balanced Ground Protection on Auto-Transformer Ties

By using a balanced ground relay of the *C D* or *I J* type, in place of the two directional ground relays described above, simple and effective protection for auto-transformers results with only one line from each of the two auto windings. This is shown in Fig. 6. An auxiliary auto current transformer may be used in the current transformer secondaries on either side of the balanced ground relay, to compensate for the ratio of transformation of the auto-transformer and also for any difference in current transformer ratios. This results in the flow of ground current through the auto-transformer balancing out in the relay circuit, leaving only the fault current put out by the auto-transformers to operate the balanced ground relay. This current will appear in the side of the relay toward the fault, making the balanced relay directional for ground protection. Although this scheme provides very little in the way of bus protection, it is very simple and effective for directional ground protection of outgoing lines tied through an auto-transformer.

High-Speed Relaying

With the advent of circuit breakers which are intended to clear faults in from 3 to 10 cycles compared with 20 to 60 cycles as heretofore, it is very evident that some marked changes in relay protection will have to be worked out immediately. Study should therefore be given to the effect of high-speed relaying at certain locations, and to the possibility of speeding up relay operation at all possible points. It will be found that ground relays are much more susceptible to improvement in this regard than are phase relays.

It would be rather easy to design and use high-speed relays and high-speed breakers if a whole system could be changed over to this equipment at once, but in many cases, it is going to be extremely difficult to use high-speed switching and relaying on one part of a system and the present day types on the rest of the system. It would therefore be advantageous to speed up the relays as much as possible on all present installations, so that the gradual changeover to high-speed switching will not mean so much revision in the protective system as a whole.

Conclusion

Experience seems to show that on high voltage transmission systems, ground relay protection is almost paramount. On many systems, the benefits of ground protection have been extended to lower voltage lines and it is recommended that more general use of ground protection be made on systems of all voltages. Ground relay protection possesses great flexibility of application and can be adapted to the further developments in protection which will undoubtedly occur shortly. The advent of high-speed ground relaying is just around the corner. In developing the relay schemes described above considerable experimental work was done and several of them were modified following tests at system voltage. It is suggested that experimental work of this kind be encouraged on many systems to further the development of protection schemes.

Abridgment of

Auxiliary Circuits for High-Voltage D-C. Motor Car Equipments

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and

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Synopsis.—The increasing demand for frequent and rapid transportation on both suburban and other railways has brought to the fore the multiple unit motor car. The steps taken in the development of the auxiliary equipment for the multiple unit motor coach are quite interesting, and have been made the subject of this paper. The first part of the paper is devoted to cars equipped with apparatus for converting the high-voltage d-c. overhead-line current to the voltages required for operating standard auxiliary equipment. The second part is devoted to auxiliary equipment suitable for operation on the higher d-c. voltages now being used in more and more electrification projects. Although this paper refers mostly to development work carried out in Europe, it is nevertheless believed to be of interest to American engineers as the basic principles underlying this development are also applicable to American multiple unit cars.

* * * * *

INTRODUCTION

WITH the continued growth of cities and the further expansion of railroad facilities, it will be necessary that in the near future many railroads will have to consider the electrification of their terminal areas, and this for several reasons, too well known to require repetition in a paper of this scope.

It has been found that for such service, the best traction equipment is motor (multiple unit) cars. There is no question that this means of transportation has proved itself to be very economical and efficient. For instance, in order to illustrate the situation, reference may be made to the New York, Chicago, and Philadelphia terminal areas, where hundreds of motor cars are in operation; the first two cases fed by 1500 and 600 volts, direct current, and the last by alternating current.

It is well known that the greatest number of multiple unit cars have thus far been used on subway, elevated, and other city railway systems. Without exception, these systems are operated by 600 to 800 volts direct current. These equipments, however, will not be considered in this paper, and reference will be made only to motor car equipments for 1500 volts, direct current and higher.

In recent years, several suburban electrifications using motor cars almost exclusively have been carried out with direct current at voltages of 1500 volts and higher. Many electrifications of suburban lines have been undertaken using direct current at voltages as high as 3000 volts, and one line in particular was electrified, and has been in continuous operation for about ten years, with 4000 volts, direct current.

Some recent d-c. main-line electrifications using motor cars for 1500 volts or higher voltages on the overhead line are the following:

Railroad	One-hour rating at wheels Hp.	Voltage
In the U. S. A.		
Illinois Central R. R.	965	1500
Chicago, South Shore & South Bend R. R.	....	1500
Piedmont & Northern R. R.	....	1500
Delaware, Lackawanna & Western R. R. (under construction)	885	3000
In Canada		
Canadian National Rys.	575	2400
In Australia		
Suburban Electrifications in Melbourne and Sydney	720 and 560	1500
In India		
Great Indian Peninsula Ry. (Bombay)	1100	1500
Bombay, Baroda & Central India R. R.	....	1500
In Java		
Java State Rys.	450	1500
In Japan		
Japanese Government Rys.	536	1500
In Holland		
Netherland State R. R.	800	1500
In France		
Midi Ry.	700	1500
Paris-Orleans Ry.	1000	1500
In North Africa		
Moroccan Rys.	700	3000
In Spain		
Spanish Northern Ry.	920	5500
In Switzerland		
Nyon-St. Cergue-Morez R. R.	385	2200
Chur-Arosa R. R.	385	2200
In Italy		
Pinerolo-Perosa-Argentina R. R.	330	2200
Biella-Oropa R. R.	380	2400
Biella-Valle Mossa R. R.	340	2400
Pescara-Penne R. R. (under construction)	380	2600
Spoleto-Norcia R. R.	400	2600
Roma-Ostia R. R.	362	2600
Fermano-Porto-St. Giorgio-Fermo Amandola R. R. (under construction)	400	2600
Sangritana R. R.	400	2600
Arrezo-Sinalunga R. R. (under construction)	580	3000
Vicena-Chiampo R. R. (under construction)	580	3000
Dolomiten R. R. (under construction)	380	3000
Norte-Milano R. R.	730	3000
Torino-Cirie-Valle di Lanzo R. R.	388	4000 (4700)
In Austria		
Peggau-Uebelbach R. R.	....	2200

It is only in recent years that multiple unit operation has been employed on motor cars at voltages higher than 1500 volts. The very first 3000-volt d-c. multiple unit motor car operation was put in service during the year

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1929 on the lines of the Norte-Milano Railroad in Italy.

Many of the lines enumerated above are not of large size so far as trackage and number of cars are concerned, especially when compared with North American railroads. Nevertheless, the basic studies had to be made, the development was undertaken, and the electrifications in all cases have proved successful.

This paper will be divided into two parts: The first deals with the power supply for the auxiliary circuits using high-voltage to low-voltage conversion equipment, a system exemplified by two typical lines, the first ever built for this type of equipment. The second part of the paper will describe in detail the development of auxiliary equipment for voltages equal to those of the overhead distribution systems.

I. Auxiliary Circuits Supplied by High-Voltage to Low-Voltage Conversion Apparatus

In a motor car there are several circuits requiring electric energy in addition to the main motor circuit. Provision must be made to supply the various auxiliary circuits with the proper voltage.

The following are the auxiliaries dealt with in most cases:

a. Control system. Power for the operation of relays, magnet valves, contactors, reversers, etc.

b. Pneumatic system. Compressed air is used on almost all electric vehicles for the operation of various apparatus, for the air brakes, whistles, sanders, etc. Frequently the brakes are vacuum operated.

c. Lighting of vehicles.

d. Heating of vehicles.

e. Other auxiliary power circuits, such as for blower motors for traction motor blowers, if they are necessary, etc.

f. Automatic train control, if used.

The insulation problem is naturally of the utmost importance in high-voltage d-c. machines, particularly when it comes to machines of small output. Very careful work during the manufacturing processes and careful inspection once the equipments are in service are necessary. When the first high-voltage motor cars were built, neither the manufacturers nor the operators thought that it was possible to operate almost all the auxiliaries satisfactorily directly from the overhead line, as is being done today. These early cars therefore were equipped with large motor-generator sets, suspended underneath the floor of the cars. These motor-generators had to be of capacity ample to furnish power to the air compressors, the heaters, the lights, and for the control system in general.

Typical examples of such equipments are the cars operating on the lines of the Nyon-St. Cergue-Morez, and the Chur-Arosa railroads, in Switzerland; both operate at 2200 volts, direct current. Each car is equipped with four motors having a combined one-hour rating of 400 hp. Speed regulation of the car for motoring as well as during electric braking is obtained by means of a manually operated cam type controller. All motor cars of both systems are equipped with motor-generator sets of 40-kw. continuous rating. This motor-generator furnishes power for all auxiliaries. The generator of this converting set furnishes power at 300 volts, which is used for the following purposes:

a. Motor of vacuum pump for air-brake system (approx. 4 kw.).

b. Motor of air compressor (approx. 3 kw.). This air is needed for the pneumatic operation of the pantograph current collectors, the main switch, the reverser of the traction motor circuit and the pneumatic rail brakes. In the system of rail brakes used on these cars, a brake-shoe is forced against the head of the rail by means of compressed air. Such rail brakes are very extensively used on railroad systems where speeds are comparatively low but where heavy grades are encountered. Rail brakes give excellent service, particularly under bad traction conditions such as in thick fog or when fallen leaves or ice cover the rails. Under those conditions the rail brakes are applied lightly and serve to clean the rails and thus improve adhesion.

If trailers are used, and especially on heavy grades, the trailing cars are retarded by means of the vacuum brakes, while the motor car is braked only electrically. In emergency cases, both air brakes (rail brake and vacuum brake) are applied, and the electric resistance brake may be used on the motor car also.

c. Lighting and heating of motor car and trailers (approx. 33 kw.). The heating elements are direct connected to the 300-volt d-c. auxiliary power system by means of snap switches.

The motor-generator set of the cars under consideration consists of a motor with single commutator, wound for direct-connection to the 2200-volt overhead line. As mentioned before, the generator furnishes 300 volts, direct current.

Motor-generator sets of later design are equipped with an additional small exciter which is especially provided to keep the generator voltage constant with varying loads and with varying primary voltages. Converter sets for outputs ranging from 1.5 to 40 kw. and for secondary voltages from 40 to 500 volts, have been built in large numbers for primary voltages up to 3000 volts.

The operation of the line switch, the pantographs, and the switch for the motor-generator are controlled by a single valve located in the driver's desk. Mechanical operation of the main controller, and pneumatic operation of the apparatus as mentioned above, results, so far as we have experienced, in the minimum amount of maintenance costs of any system of control. This system, however, is not suitable for multiple unit motor car operation, but has shown excellent results on equipments of the type just described.

II. Development of Auxiliary Equipment Operating at the System Voltage

It was soon realized that it was not economical to equip all motor cars with large motor-generator sets, as on these first high-voltage electrifications; particularly when the outputs of the cars kept increasing, and in many cases higher outputs were necessary due to the fact that more trailing cars were pulled by the motor cars which required more power for heating and lighting, larger compressors also had to be used.

a. Compressor Motor. High-voltage auxiliary motors

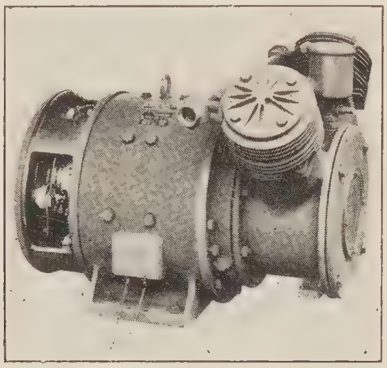

Fig. 7—Motor Compressor for 1500 Volts, Direct Current

were then developed, and first employed in connection with the air compressors. Such a motor compressor for 1500-volt d-c. operation is shown in Fig. 7. Hundreds of such compressors are in operation on various

Fig. 8—Turn-Button Switch for Heating Circuit

railroad systems. Today compressor motors are being run directly on the 3000-volt trolley lines.

As a consequence, the motor-generator sets could be considerably reduced in size. The sets used today average from about 1.5 to 2.5 kw.

b. Heating Circuit. Parallel with the development of high-voltage auxiliary motors was undertaken the development of heaters for high-voltage d-c. circuits. The results were such that for a great number of years, car heaters have been direct-connected to circuits of 3000 volts and higher. As early as 1920 we saw an undertaking which at that time was considered very risky, and was not duplicated for many years: it was the connection of car heaters directly to a 4000-volt d-c. system. The Torino-Lanzo-Ceres Railroad Co. in Italy, which operates its system at that voltage, had the

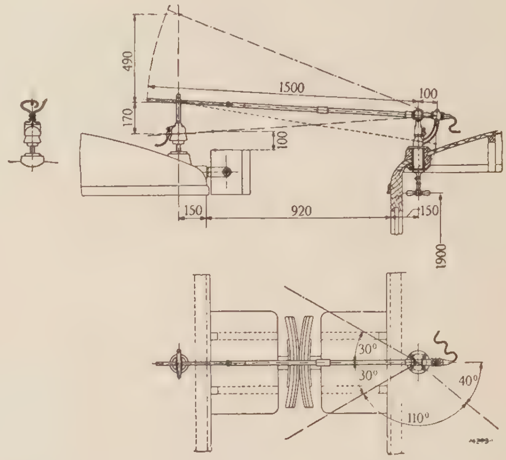

Fig. 9—Rod Coupling for Heating Circuit

courage to undertake what was then believed impossible. This, however, proved to be a complete success.

Heating circuits in high-voltage d-c. equipments have controllers of special design. A switch for 2600 volts direct current and about 5-kw. interrupting capacity, suitable for mounting inside the passenger compartment, is shown in Fig. 8.

The heating of several cars in a train from a motor car naturally requires special couplings between the cars. In many countries, connectors located on the roof at the ends of the cars have been used. Such a coupling is shown in Fig. 9. The comparatively small currents taken by car heating systems at high voltages

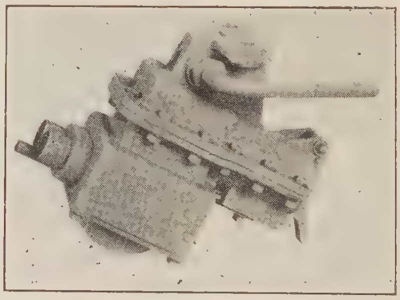

Fig. 10—Train-Heating Coupling for 400 Amperes 3000 Volts, D-C. or A-C.

can readily be handled by couplings of such a design. For large current ratings, the above-mentioned coupling naturally is not suitable, and heavier couplings had to be developed.

Heating couplings of high current-carrying capacities are usually built for one pole only. A coupling designed for 400 amperes continuous current at 3000 volts is

shown in Fig. 10. It is therefore possible to carry approximately 1200 kw. at that voltage with a coupling of this type.

It is desirable not to disconnect the coupling while the power is on. For this purpose an auxiliary contact is provided, by means of which the holding circuit of the heating system main switch, normally located in the motor car, is opened, and the circuit interrupted before the coupling contacts separate. Several thousand such couplings are in service, at voltages of 1000 to 1500 volts, without having any interlocking contacts at all.

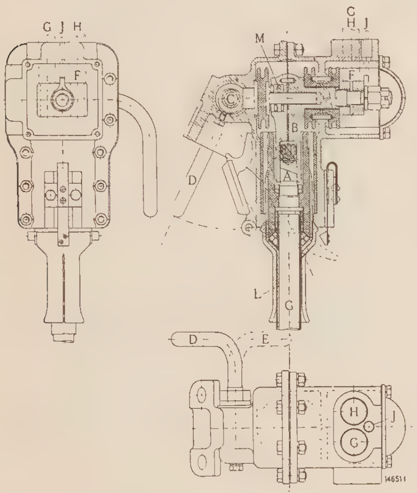

Fig. 11—Coupling Box and Pin for Train-Heating Circuit

A. Contact pin
B. Clamp in two parts
C. Eccentric
D. Eccentric lever in open position (contact loose).
E. Eccentric lever in closed position (contact clamped)
F. Cable terminals
G. Cable connecting the coupling box and pin
H. Cable connecting the two coupling boxes
J. Cable going to the heaters
K. Handle of plug
L. Ground wire
M. Spring
N. Insulating tip

A section through such a coupling is shown in Fig. 11. A coupling with an interlocking contact is shown in Fig. 12.

From the above it can be seen that the tendency prevails to connect directly to the high-voltage circuit, as many of the auxiliaries as possible and do away with all converting apparatus.

c. *Control Current and Lighting Circuits.* There are two other circuits which require a power supply which up to now have not been—and probably never will be—connected directly to the high-voltage system of the motor car. These are the circuits commonly known as the control current and the lighting circuit.

For a considerable period of time the control current for 600-volt d-c. systems has been taken from the main power circuit, series resistances being inserted into the circuit to permit the use of standard relays, magnet valves, and other apparatus which are necessary for the control of the car, but which are not built for such high voltages. In newer equipments, the control circuits and the lights are supplied directly from motor-generator sets in which control voltages are as high as 300. Still more modern equipment is usually furnished with the control circuit fed from a storage battery in combination with a motor-generator provided for charging the battery, or combined with a battery and a train-lighting axle generator. The voltages employed vary greatly, and equipments are in operation at voltages of 12, 14, 18, 24, 32, 36, and even 48 volts. If motor-generators are used, machines with an output of from about 1000 to 1500 watts are sufficient to take care of the lighting and control-current requirements.

Evolution of Auxiliary Equipment. Some cars of the Torino-Lanzo Railroad which were placed in operation in the year 1920 were already equipped with axle generators, to which the lights and the control-current circuit were connected. In this particular case the compressor motor was also driven by this axle generator. The average voltage of this system, which is used in conjunction with a storage battery, is 48. The axle generator is designed for a continuous output of 3.5 kw. The motor of the compressor is built for an intermittent rating of 2 kw. A second compressor, mechanically driven, was furnished for these cars.

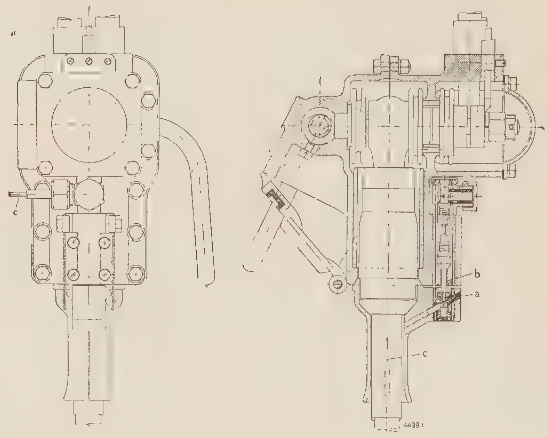

Fig. 12—Coupling for Train Heating with Safety Interlocking Device

a. Interlocking contact on the plug
b. Interlocking contact on the coupling box
c. Auxiliary cable

This compressor was connected with one of the truck axles. The system of having two compressors, one also operable from the battery in case the train is not moving, and the other connected directly to an axle, has decided advantages. On this line, grades up to 3.5 per cent are encountered, but due to the above described system of two compressors it is possible to descend safely all grades on the line, even when the power fails.

With the solving of the main power and control-current problems, as on the Torino-Lanzo and later electrifications, solutions have been worked out which

have resulted in the present day high-voltage d-c. equipments.

The most modern 3000-volt d-c. traction system, where multiple unit motor cars were utilized for the first time, was put in operation by the Norte-Milano Railroad Company in Italy during the spring of 1929. The entire d-c. power supply of this railway system is furnished by mercury arc rectifiers (6000-kw. units). The motor cars, as well as the trailers on this line, are of modern steel-car design. Each motor car is equipped with four axle-suspended motors, of a one-hour rating of approximately 190 hp. The motors are of the self-ventilated type. The compressor motor is connected directly to the overhead line, the necessary apparatus, such as compressor governors and contactors, being connected into this circuit at the proper places. The heaters of the motor cars and trailers are also fed from the overhead line, and are controlled by means of suitable controllers. Control current, as well as power for the lights, is furnished by the axle generator at an average voltage of about 36. The trailing cars are also equipped with train-lighting generators. The current for heating the trailers, however, is furnished from the motor car, and couplings similar to those shown in Fig. 9 are utilized for the interconnection between the cars.

Protection of the high-voltage auxiliary circuits against excessive currents is accomplished by fuses.

From the above it can be seen that great contributions toward the development of high-voltage d-c. motor car equipments have been made during recent years. From all indications which we have on this matter and also from the experience gained with equipments now in service, we feel sure that the use of high-voltage d-c. motor cars for passenger transportation in the future presents itself as a technically and economically sound solution of many transportation problems.

Abridgment of

The Transmission Characteristics of Open-Wire Telephone Lines

BY E. I. GREEN*

Associate, A. I. E. E.

Synopsis.—*Values of the primary transmission constants R, L, G, and C for open-wire telephone lines are presented, and the factors which affect these constants in practice are discussed. Consideration is then given to the constants which are of principal interest in telephone work, namely, attenuation, characteristic impedance, phase constant, and velocity of propagation. Data regarding these characteristics are given for the frequency range from 0 to 50,000 cycles.*

Introduction

NEARLY 3,000,000 mi. of open wire are now furnishing toll service in the Bell System, and this total is increasing at a rate of more than 100,000 mi. a year. Hence the subject of transmission characteristics of open-wire circuits, in addition to being of considerable natural interest, is of no little importance in telephone work. Alike in the design of apparatus to be associated with the open-wire circuits and in the engineering and maintenance of the facilities derived from them, a knowledge of these transmission characteristics is indispensable.

The problem of determining the characteristics of the open-wire circuits dates back to the beginnings of telephony. Of late years, however, there has been a very decided change in the nature and scope of the problem. This has resulted from many factors, particularly (1) the extensive application of carrier telephone and telegraph systems, and (2) the constantly increasing length of long-distance circuits. The first factor has extended the transmission range upward from about 3000 cycles to about 30,000 cycles, and may well extend it further in the future. The second, in combination with the higher standards now applied in long-distance transmission, has required greater accuracy in the data, emphasizing especially the importance of time and space variations in the characteristics.

There will be studied in this paper those inherent characteristics of open-wire lines which are used most frequently in telephone transmission work. These characteristics are: (1) attenuation, (2) impedance, (3) phase characteristic, with which must be coupled its near relative, velocity of propagation. The range of frequencies to be covered extends from 0 frequency to about 50,000 cycles.

Line Construction Arrangements

In order to study the characteristics of open-wire lines, it is necessary to know something of the constructional arrangements which are employed. The conductors most commonly used for open-wire telephone lines of the Bell System are of 165-mil (No. 8 B. W. G.), 128-mil (No. 10 N. B. S. G.), and 104-mil (No. 12 N. B. S. G.) hard-drawn copper. Common configuration for an open-wire line is illustrated in Fig. 1. There has recently come into vogue a different arrangement of wires, designed to reduce the coupling between

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circuits and thus permit a maximum use of carrier facilities.

Primary Constants

A review of the well-known theory for the propagation of alternating currents over wires will show that the line characteristics in which we are interested are

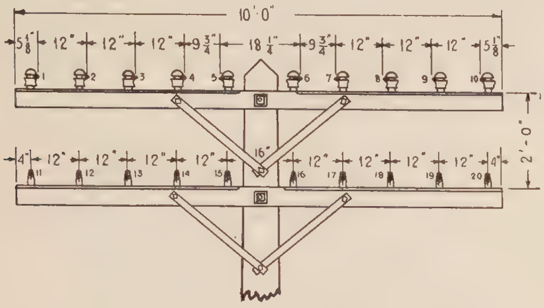

Fig. 1—Configuration of an Open-Wire Line with 12-In. Non-Pole Pairs

dependent upon the four quantities known as the primary constants of the circuit. These are as follows:

R—Series resistance in ohms per mi.
L—Series inductance in henrys per mi.
C—Shunt capacitance in farads per mi.
G—Shunt leakage conductance in mhos per mi.

These quantities will be stated per mile of circuit (or per "loop mile").

Resistance

First in the list of primary constants is generally named the conductor resistance. The method of computing both the d-c. and a-c. resistance of round wires

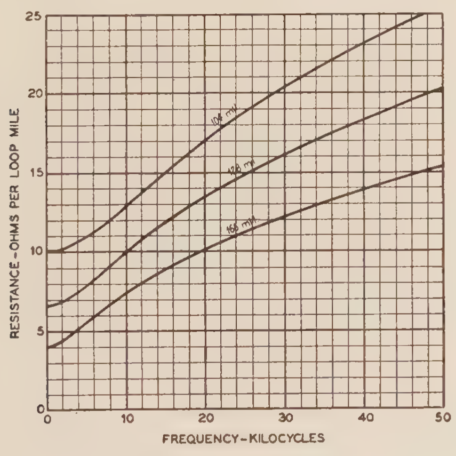

Fig. 5—A-C. Resistance of Open-Wire Pairs at 20 Deg. Cent. (68 Deg. Fahr.)

is well known. Values of the a-c. resistance of 165-, 128-, and 104-mil copper pairs at 20 deg. cent. (68 deg. fahr.), determined in accordance with the usual skin-effect theory, are plotted in Fig. 5. It will be noted that the increase in resistance due to skin effect is small in the voice range, but rather astoundingly large at carrier frequencies, ranging from 200 per cent to nearly 400 per cent. Experimental evaluations of open-wire resistance are in extremely close agreement with the values given in Fig. 5.

Like the d-c. resistance, the a-c. resistance of a copper wire varies with temperature. The percentage change in the a-c. resistance for a given change in temperature, however, is less than the percentage change in the d-c. resistance. As illustrated in Fig. 6, the a-c. temperature coefficient of resistance for open-wire pairs, starting at the d-c. value, straightway decreases as the frequency is increased, and at high frequencies approaches a value which is half of the d-c. coefficient.

Inductance

The inductance of a circuit formed of two parallel wires whose distance between centers is negligible compared with their length is

$$L = 0.64374 \left[2.3026 \log_{10} \frac{2D}{d} + \mu\delta \right] \times 10^{-3} \text{ henrys per loop mile} \quad (3)$$

where the diameter of each wire d and the distance between their centers D are expressed in the same units,

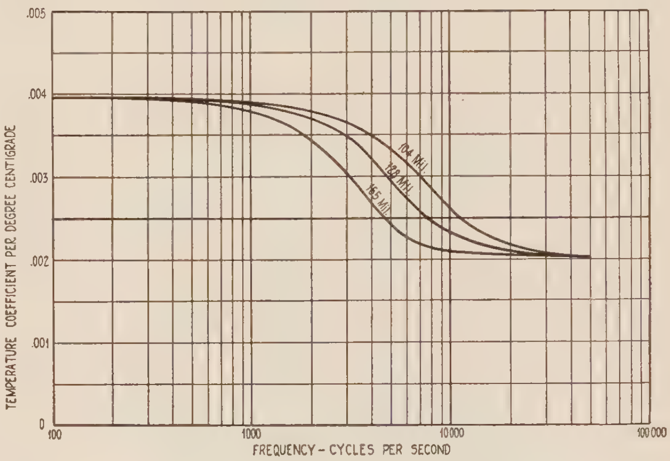

Fig. 6—A-C. Temperature Coefficient of Resistance for Open-Wire Pairs at 20 Deg. Cent.

where μ is the permeability and δ is a factor depending on the frequency. The tendency of alternating currents to concentrate on the surface of a wire reduces the magnetic flux within the wire, so that the internal inductance decreases as the frequency is increased. For the wire diameters and spacings employed on open-wire lines, however, the change in the total inductance due to skin effect is relatively small. The d-c. inductance of 165-, 128-, and 104-mil copper pairs, having various spacings between wires, is shown in the following table:

	Inductance—henrys per loop mile		
Wire spacing	165-mil	128-mil	104-mil
8 in.	0.00311	0.00327	0.00340
12 in.	0.00337	0.00353	0.00366
18.25 in.	0.00364	0.00380	0.00393

The values of inductance given in this table have been closely checked by measurements on open-wire lines.

Capacitance

The capacitance of two parallel wires in space with

a distance between centers which is negligible compared with their length is

$$C = \frac{0.019415}{\log_{10} \dfrac{2\,D}{d}} \times 10^{-6} \text{ farads per loop mile} \qquad (4)$$

The capacitance of a pair is changed to an appreciable extent by the presence of other wires, and to a slight extent by the capacitance to ground. Values of the capacitance of 165-, 128-, and 104-mil pairs in space and on a 40-wire line are given in the following table:

	Capacitance— μf per mile					
	165-mil		128-mil		104-mil	
Wire spacing	In space	On 40-wire line	In space	On 40-wire line	In space	On 40-wire line
8 in.	0.00977	0.00996	0.00926	0.00944	0.00888	0.00905
12 in.	0.00898	0.00915	0.00855	0.00871	0.00822	0.00837
18.25 in.	0.00828	0.00863	0.00791	0.00825	0.00763	0.00797

The means of insulation and support provided at each pole have an appreciable effect on the capacitance of a pair of wires, especially in wet weather.

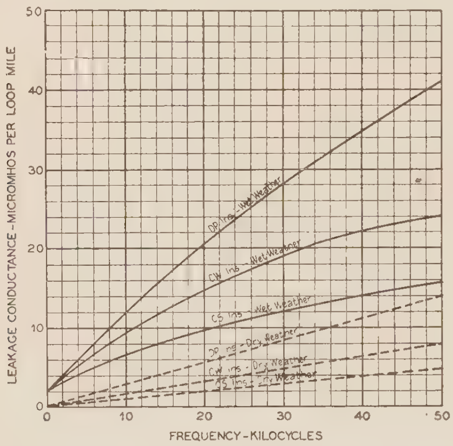

FIG. 8—LEAKAGE CONDUCTANCE OF OPEN-WIRE PAIRS EQUIPPED WITH DIFFERENT TYPES OF INSULATORS

The inductance and capacitance of a pair may be changed to an appreciable extent by changes in the spacing between wires which result from the presence of transpositions.

LEAKAGE CONDUCTANCE

The leakage conductance per unit length of circuit, which is represented in the transmission formulas by the symbol G, is by far the most erratic of the primary constants. For alternating currents it is customary to employ an equivalent value of G which includes all of the losses suffered by the power transmitted over the pair except the normal $I^2 R$ loss in the wires themselves. Practically all of the losses comprehended in the term G occur at the insulators. The nature and magnitude of these losses for different types of insulators are discussed in detail in a parallel paper.[6]

In view of the numerous and complex sources of leakage loss, it is not surprising that the leakage conductance for a given pair at a particular frequency varies with changing weather conditions and with the age of the insulators over a very wide range of values. It is possible to give here only selected leakage values which serve for engineering pusposes. Fig. 8 presents values of the total leakage conductance for open-wire pairs equipped with different types of insulators. The wet weather values have been so chosen that they should be exceeded on only a few days of the year, while the dry weather values represent the performance that should be expected from any circuit on a clear, dry day.

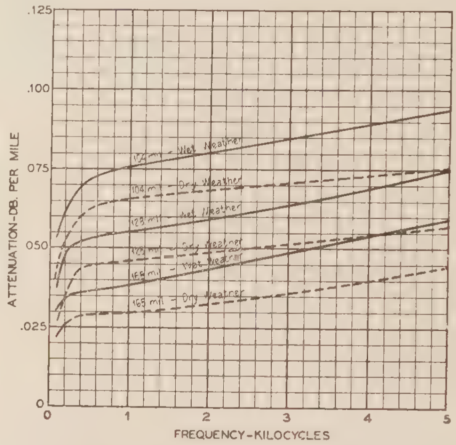

FIG. 9—VOICE-FREQUENCY ATTENUATION OF OPEN-WIRE PAIRS EQUIPPED WITH D P INSULATORS

Study has been given to methods of reducing leakage conductance, particularly at carrier frequencies, and two new types of insulators (C S and C W) have been developed for this purpose. In these there is used an improved dielectric (borosilicate glass) which has a low power factor and a reasonably low dielectric constant, as well as good chemical stability. With these two types of insulators a substantial reduction in the total leakage conductance is brought about, as will be evident from Fig. 8. A further advantage obtained through the application of the new insulators is that of stabilizing the leakage, and attenuation, at carrier frequencies.

ATTENUATION

The attenuation constant is the real part α of the propagation constant γ as given in the familiar formula

$$\gamma = \alpha + j\,\beta = \sqrt{(R + j\,L\,\omega)\,(G + j\,C\,\omega)} \qquad (5)$$

An approximate formula for the attenuation of open-wire circuits at carrier frequencies is as follows:

$$\alpha \doteq \frac{R}{2}\sqrt{\frac{C}{L}} + \frac{G}{2}\sqrt{\frac{L}{C}} \qquad (7)$$

The first term of (7) represents the series losses and is commonly referred to as the "resistance component" of attenuation, while the second term represents the

6. See A Study of Telephone Line Insulators, by L. T. Wilson, presented at the Summer Convention of the A. I. E. E., Toronto, Can., June 23-27, 1930.

shunt losses and is called the "leakage component" of attenuation.

Values of the attenuation constant of open-wire pairs of different gages when equipped with d. p. insulators are presented in Figs. 9 and 10. The attenuation curves shown are strictly applicable to pairs having a wire separation of 12 in., but they are approximately correct for spacings of 8 and 18.25 in.

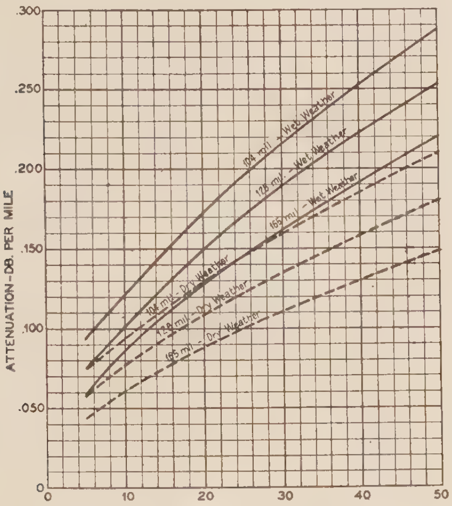

FIG. 10—CARRIER FREQUENCY ATTENUATION OF OPEN-WIRE PAIRS EQUIPPED WITH *D. P.* INSULATORS

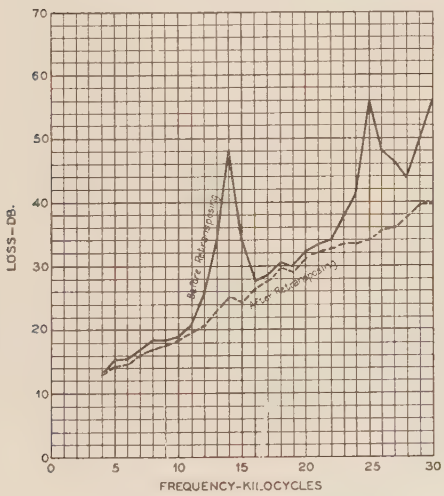

FIG. 14—ABSORPTION PEAKS ON AN OPEN-WIRE PAIR

The attenuation of an open-wire pair varies from time to time over a wide range of values, and it is, therefore, not to be expected that the values of attenuation measured at any particular time will necessarily coincide with the theoretical values. Furthermore, the attenuation measured on an actual pair never bears the perfectly smooth relation to frequency which is shown on the computed curves, but exhibits irregularities varying in magnitude according to the irregularities existing on the line.

Inductive or conductive coupling between a pair and the other circuits on the line may result in the absorption of energy in these other circuits. Fortunately the losses due to this cause are small on well-transposed lines. On inadequately transposed lines, however, this interaction with other circuits, in addition to producing

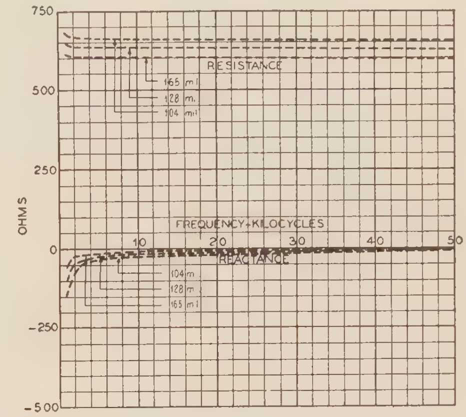

FIG. 15—CARRIER-FREQUENCY IMPEDANCE OF 12-IN. OPEN-WIRE PAIRS

small losses over a wide range of frequencies, may cause incredibly large losses in a narrow band of frequencies, thus producing what is known as an "absorption peak" in the attenuation curve. This interesting phenomenon is illustrated in the attenuation curves of Fig. 14, which show how two very pronounced absorption peaks on a line about 300 mi. in length were smoothed out by the application of improved transpositions.

IMPEDANCE

The characteristic impedance is defined by the well known formula:

$$Z_0 = \sqrt{\frac{R + j L \omega}{G + j C \omega}} \text{ ohms} \tag{8}$$

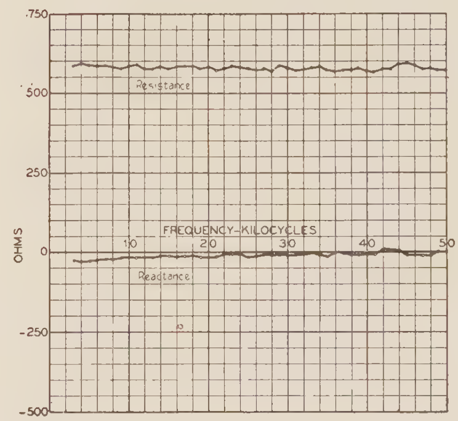

FIG. 16—IMPEDANCE MEASURED ON A WELL-TRANSPOSED 128-MIL OPEN-WIRE PAIR WITH 8-IN. SPACING

At high frequencies, the approximate value of Z_0 is

$$Z_0 \doteq \sqrt{\frac{L}{C}} \tag{9}$$

It will be noted that this impedance is a pure resistance.

Values of the characteristic impedance in dry weather of open-wire pairs with 12-in. wire spacing are presented in Fig. 15. The basis for the impedance value of 600 ohms resistance, which has become almost a tradition in so many phases of telephone work, will be obvious from this figure. The impedance curves for pairs with 8 and 18.25-in. spacing are similar to those of Fig. 15.

The measured impedance is never a smooth function of frequency but displays slight irregularities throughout the entire range. This is apparent from Fig. 16, which gives a curve of the impedance measured on a well transposed pair.

PHASE CHANGE AND VELOCITY OF PROPAGATION

The imaginary component β of the propagation constant is the phase constant. This constant enters into the familiar expression for the velocity of propagation.

At frequencies above a few hundred cycles the velocity of propagation on open-wire lines approaches the velocity of light. The velocity is reduced below this value by capacitance resulting from the other wires and the insulators, by internal inductance, and by the presence of resistance and leakage conductance.

CHARACTERISTICS OF PHANTOM CIRCUITS

Phantom circuits, which are derived from two pairs or side circuits by transmitting over the wires of one pair in parallel and using the wires of the other pair in parallel as a return, are used principally for voice-frequency transmission. In general, the attenuation of a phantom circuit is somewhat less than that of the corresponding side circuit. The impedance of a phantom circuit averages about 60 per cent of the impedance of a side circuit.

CHARACTERISTICS OF IRON WIRE CIRCUITS

There now exists on the toll lines of the Bell System a small amount of galvanized iron or steel wire. The iron wire pairs display such large values of modulation and high-frequency attenuation that they are generally quite unsuitable for carrier transmission. Because of its high d-c. resistance and the large skin-effect ratio which results from its high permeability, the resistance of iron wire for alternating currents is extremely great. The attenuation of an iron wire circuit averages about ten times that of the corresponding copper wire circuit. The impedance of an iron-wire circuit has the same order of magnitude as the impedance of a similar copper wire circuit.

Abridgment of

Standards of Insulation and Protection for Transformers

BY J. ALLEN JOHNSON[1]
Fellow, A. I. E. E.

and

EDWIN S. BUNDY[2]
Associate, A. I. E. E.

Synopsis.—*This paper presents the reasons and evidence which have influenced the authors to favor the proposed recommendations on relation of transformer insulation to adjacent line insulation set forth in a companion paper by Messrs. Montsinger and Dann.*

The paper first outlines the principal considerations which govern the determination of transmission line insulation on one hand, and transformer insulation on the other. It concludes that the line insulation is a service problem requiring a unique solution whereas the transformer insulation is a manufacturing problem requiring a standardized solution. True coordination of one with the other therefore seems impossible, indicating the need for protective measures at the point of contact.

Considerations affecting the selection and characteristics of such protective measures are discussed briefly, and the reasons outlined for believing that at present service experience is a better criterion than research tests upon which to decide such selection.

Twenty-five years' service experience on the system now controlled by the Buffalo, Niagara and Eastern Power Corporation, with protective gaps similar to those recommended as one of the proposed protective measures, is described, and conclusion drawn that the use of such gaps under suitable conditions constitutes a satisfactory protective measure.

* * * * *

THIS general subject was first brought to the attention of the Institute in a formal way by two papers[3,4] presented in 1928.

Following the presentation of these two papers, the question was referred to the Transformer Subcommittee of the Electrical Machinery Committee. After long consideration, this subcommittee formulated for insertion into the Institute Standards for Transformers a proposal defining the conditions, with respect to surge voltages, under which standard transformers might safely be operated. The proposed provisions are included in the companion paper by Messrs. Montsinger and Dann.

The problem has been precipitated by the trend

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Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Canada, June 23-27, 1930. Complete copy upon request.

3. *Relation Between Transmission Line Insulation and Transformer Insulation*, W. W. Lewis, A. I. E. E. Quarterly TRANS., Oct. 1928, Vol. 47, p. 992.

4. *Rationalization of Transmission System Insulation Strength*, Philip Sporn, A. I. E. E. Quarterly TRANS., Oct. 1928, Vol. 47, p. 998.

toward higher standards for transmission line insulation than prevailed at the time the present standards for transformer insulation strength were adopted, and takes the form of a question as to whether transformer insulation strength should be increased or transformer protection standardized.

The purpose of this paper is to record some of the considerations which influenced the writers (one of whom is a member of the Transformer Subcommittee) to favor the proposed method of dealing with this situation. These considerations relate, first, to certain factors which appear to govern the rational choice of line and transformer insulation strength; and second, to operating experience with a system of protection similar to one of those proposed.

Considerations Governing Selection of Line Insulation

It is now universally recognized, of course, that if they are to render acceptable service from the standpoint of continuity, long transmission lines must be insulated against lightning rather than merely for the operating voltage. Just how strong the insulation should be is a unique economic problem in each particular case, governed by a number of factors.

In a territory subject to a given statistical number of lightning storms per year producing a given number of discharges per unit of area, the number of outages occurring on a given transmission line will be a function of two factors which may be broadly and briefly stated as (1) strength and (2) length. The number of interruptions per year on a given line, other things being equal, will be in proportion to an inverse function of its insulation strength and a direct function of its length. During the past few years we have become accustomed to sum up the insulation performance of a transmission line in terms of flashovers per mile per year; but unfortunately, the standard of service to customers dependent upon the continuity of the line, which is the basic determining factor, depends not upon the number of interruptions *per mile* per year, but upon the *total* number of interruptions per year. Thus it follows that if equal service is to be rendered by lines of unequal length, the insulation strength must be varied in inverse proportion to the length of the line.

Another factor which bears on the question is whether it is the only line supplying the load, or whether there are other lines supplying the same load either from the same source of from different sources. It is obvious that for a given quality of service to the customer, a single supply must be better insulated than a properly relayed multiple supply.

Another set of factors involved is the frequency and severity of storms in the territory traversed by the line. A line traversing territories differing in these respects may have its insulation varied accordingly. Of similar import is the profile of the right of way or of the line itself. A high river crossing for instance, is often more heavily insulated than the remainder of the same line.

Still another factor is that of earth conditions which may affect not only the level of the conducting plane with relation to the transmission wires but also the resistance of the tower foundations to earth, both of which may, in appropriate circumstances, affect the frequency of flashover of a given insulation.

The presence or absence of ground wires and other protective devices is still another factor of importance.

Considerations Governing the Selection of Transformer Insulation

In the first place, it is obvious that transformers connected to overhead transmission circuits must be built to withstand lightning surges to some degree. The only question is as to the degree of strength which they should possess. There are three alternatives: (1) The transformers may be built to withstand the maximum surges which they can receive from any line; (2) the transformers may be built "special" for each installation, to withstand the maximum surges which can be received from the actual transmission lines; or (3) the transformers may be built to withstand surges of a definite maximum amount and protected against surges of a higher value.

Under the first alternative, it would be necessary to build all transformers to withstand direct strokes of lightning. It seems obvious that if this were possible at all, its cost would be quite uneconomical and entirely out of the question.

Under the second alternative, since practically every transformer built would have different conditions to meet, they would all be different and standardization of transformers would of course have to be abandoned.

We are therefore forced to the adoption of the third alternative; namely, the standardization of transformer insulation to withstand surges of limited magnitude. This also involves the problem of protecting the transformer against surges of greater magnitude than it is designed to withstand. Both of these problems, it should be observed, are questions of standardization.

To summarize, it is evident that the transformer is a manufacturing problem and calls for a standardized solution, whereas the line is a service problem and demands an individual solution. Coordination between the two, therefore, appears quite impossible.

There are two ways in which the strength of the transformer insulation might be fixed; one way would be to determine the characteristics and magnitude of the lightning surges to which transformers are subjected, devise ways of reproducing such surges in the laboratory in order to learn the surge resisting properties of insulation, and then use these data to design transformers to withstand such surges. Another way would be to build transformers and put them in service where they will be subjected to the actual lightning surges, and learn by experience.

The next question is whether the present standards

for transformer insulation are satisfactory or whether new standards possibly more closely related to the higher average strength of modern transmission line insulation should be adopted. Since transformers of many millions of kv-a., built under present standard specifications, are already giving satisfactory service, there would seem little point now in establishing a new standard at a different level, especially as protection against surges of magnitude greater than those which the transformers would be designed to withstand would always be necessary, regardless of the actual level of insulation strength chosen as standard.

Protection of Transformer Against Excessive Lightning Surges

If this conclusion is accepted, the problem of protecting the transformer against surges too severe for it to withstand, still remains. Again, there are two ways in which we can proceed: The first alternative is to specify exactly the magnitude and characteristics of the maximum surges which the transformer will withstand, leaving the user to determine as best he may the required protection. This alternative demands intricate scientific knowledge of natural surges and of the behavior of insulation, which is not now, and may never be completely available.

The second alternative is to standardize the characteristics of protective devices. Such devices may be much simpler and their characteristics much more easily determined and closely controlled than those of the transformer. They therefore may lend themselves much more readily to standardization with respect to surge voltage characteristics. Such devices may be separate pieces of equipment or a part of the transformer.

Such protective devices may be selected not only with reference to the characteristics of the transformers but also with respect to the requirements of the service. For instance, if the service requirements should make it necessary to protect the transformer against surges without interruption of the circuit, a protective device of one character may be indicated. On the other hand, if the service requirements permit an interruption of the circuit to protect the transformer, then a somewhat different, and possibly less costly, device may be justified.

Having come so far, one more question remains; namely, is the protection of standard transformers against lightning surges a proper subject for Institute standardization? To the writer it seems that it is. Certainly it is, if the protective device is made a part of the transformer. In any case, the surges to which a transformer is subjected are a part of its environment in the same sense that the elevation, ambient temperature, weather exposure, and circuit current and voltage conditions are parts of its environment. In these other respects, the Institute Standards do not hesitate to specify the limiting conditions to which the transformer s adapted, and there would seem to be no reason why they should not also specify the limiting conditions as to lightning surges.

If this is conceded then again we are faced with the choice of either the scientific or the practical procedure, and again we find that the scientific procedure involves knowledge which is not available, while the practical procedure can be based on simple laboratory tests and experience which can be shown to have given satisfactory results.

Experience with Protective Gaps

When the first 60-kv. transmission line was constructed across the western half of New York State, in 1905 and 1906, between Niagara Falls and Syracuse it was necessary to work out some scheme for the protection of the terminal apparatus against lightning and switching surges.

In 1920 the design of station horn gaps was changed to make a much simpler and smaller structure. At this time the gaps for the three phases were mounted on one structure and the resistance grounds eliminated. The construction adopted was as shown in Fig. 3, and in general, this type of construction is in service today. The insulator supporting the line wire is equipped with two horns as shown. Another insulator mounted adjacent to the line insulator supports the horn making up the fused, or smaller gap, and this horn is connected through a disconnecting switch and expulsion fuse to ground. The fuse tube used is made up of a 1½-in. micarta tube with a ¾-in. bore, 6 ft. 6 in. long, bound with torpedo twine. The fuse wire used is No. 26 B & S copper. The dead ground gap is made up of a bent angle mounted on the structure itself and thoroughly grounded. On the 60-kv. system, the fused gap is normally set at 7 in. and the dead ground gap set at 10 in., corresponding to 60-cycle flashover values of approximately 75,000 and 100,000 volts.

The type of construction shown in Fig. 3 has been built in several forms; mounted on both wood and steel poles, with two and three poles for the supporting structures, with standard pin type and post type insulators, and with a hinged fuse tube eliminating the disconnecting switches. At the newer and larger 60-kv. stations, the dead grounded gaps are mounted on the top of the structure as shown in Fig. 4

On the 110-kv. system the same general type of construction has been used, except that the spacing and insulation have been increased On the main 110-kv. structures, which are made up of latticed beams and columns, the gaps have been mounted on top as shown in Fig. 6. In this case, the fuses are mounted near the ground on a separate beam and are hinged so that no auxiliary disconnecting switches are needed.

The gaps on the 110-kv. system are set at 13 in. and 18 in. corresponding to 60-cycle flashover values of approximately 150,000 and 250,000 volts.

The proper gap settings have been determined largely

by experience. On the 60-kv. system operating at 25 cycles, the switching surges are not severe, and only slight changes have been made since the first gaps were put in service. On the 110-kv. system, the first gaps were installed in 1925 when the entire system consisted of two parallel lines 40 mi. in length. The gaps were first set at 11 and 14 in., but it was found that switching

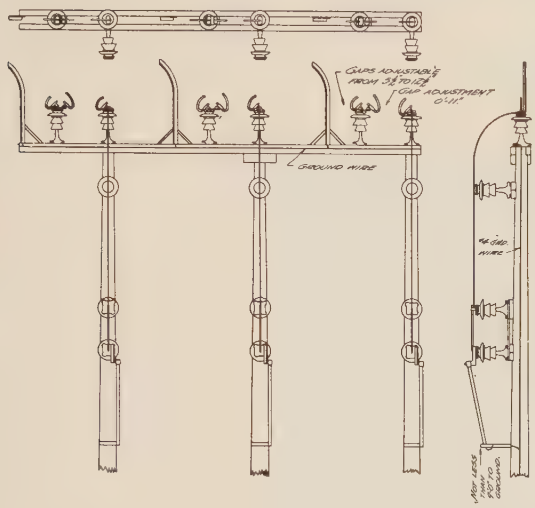

Fig. 3—Present Form of 60-Kv. Station Lightning Protection Used by Niagara, Lockport and Ontario Power Company—Adopted 1920

Fuse gap 7 in.; 75-kv. 60-cycle flashover. Ground gap 10 in.; 100-kv. 60-cycle flashover

under some conditions would cause the fused gaps to arc. The gaps were then increased in length to 12 and 15 in., and no trouble was experienced until the system became more extensive and the length of circuits switched at one point became greater. It was finally found that with settings of 13 and 18 in., no trouble

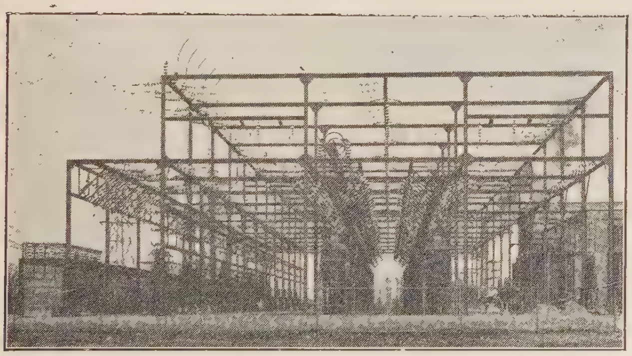

Fig. 4—John L. Harper Station of The Niagara Falls Power Company Showing Safety Gaps on 60-Kv. Structure

resulted from switching and the records show that no failures of equipment connected to the 110-kv. system have occurred.

On both the 60-kv. and 110-kv. systems, the operation of the horn gaps has been very successful in protecting the terminal equipment, since there have been practically no failures during lightning storms. There have been many cases where the fused gaps arced over, blowing the fuses without arcing across the wider settings of the dead grounded gaps. In most cases when the dead grounded gaps have arced over, the breakers controlling the line have tripped; but since practically all main stations or points of delivery are supplied over two or more circuits, interruptions have not followed.

During the progress of this development, the line insulation has been progressively strengthened to withstand lightning surges and give the required character of service. As a result, both 60-kv. and 110-kv. long distance lines now carry the same standard insulation of seven units, though certain short 60-kv. lines are operating entirely successfully with four units. In all cases, the standard line insulation is maintained right to the station structure.

Comparison of the above safety gaps with those proposed by the Transformer Subcommittee for insertion

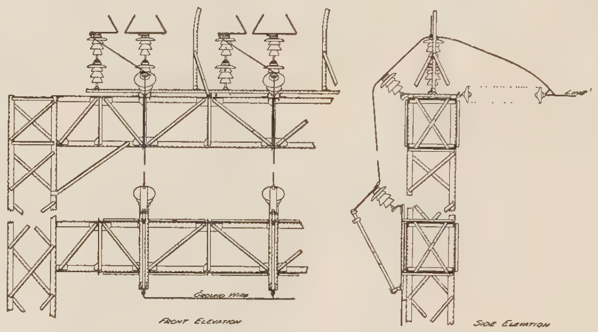

Fig. 6—Present Form of 110-Kv. Station Lightning Protection Used by Niagara, Lockport and Ontario Power Company

Fuse gap 13 in.; 150-kv. 60-cycle flashover. Ground gap 18 in.; 250-kv. 60-cycle flashover

in the Standards, as shown in tabulation below, reveals that the gap flashover voltages actually used on the system described, are considerably lower than those recommended as standards.

TABLE I

COMPARISON OF B. N. & E. PRACTISE WITH PROPOSED STANDARDS

60-Cycle Dry Flashover Voltages

Nominal line kv.	Proposed standard gaps kv.	B. N. & E. system flashover kv.		
		Line insulation	Fused gaps	Ground gap
69	185	255 (4 units)	75	100
69	185	400 (7 units)	75	100
115	300	400 (7 units)	150	250

Since the evidence of actual operation shows that the smaller gaps do not cause unnecessary interruptions, it is obvious that the recommended gaps will not do so under like conditions. On the other hand, in view of the relatively complete knowledge of the surge characteristics of gaps, there would seem to be no doubt that the recommended gaps will give adequate protection to the transformers.

INSTITUTE AND RELATED ACTIVITIES

The Summer Convention at Toronto

The opening of the Convention is taking place as this issue of the JOURNAL goes to press. A complete account of its various phases will appear in the August issue of the JOURNAL.

It is hoped that the efforts of the General Convention Committee which has made very extensive plans will be rewarded by a substantial attendance, all thoroughly enjoying the excellent features offered by this convention. The technical program is even more extensive than it has ever been before, forty-five papers and fifteen Technical Committee reports being scheduled in eight technical sessions.

Pacific Coast Convention

SPLENDID TECHNICAL PROGRAM AND ENGROSSING ENTERTAINMENT WITH AN OPPORTUNITY TO SEE THE NORTHWEST

The Convention will be held Sept. 2-5, this year at Portland, Oregon, with headquarters in the Multnomah Hotel, and members are urged to plan their vacations to include its opportunities. The Northwest is rapidly becoming a very popular summer playground, and Portland, situated in the center of this recreation area, is a convenient starting center from which to travel to the many points of interest in the territory.

Five technical sessions, two Student Branch sessions and a Conference on Student Activities by the Counselors' Committee from Districts 8 and 9 comprise the business side of the program, while ample provision is being made for diversion and entertainment.

Engineering Papers

From a wealth of material offered for the convention, eighteen papers have been tentatively selected by the Program Committee in charge of H. H. Cake. The subject matter of these papers deals with the following fields of electrical activity: Communication; Power Stations; Transmission and Distribution; and Research and Development, the titles and names of the authors of the papers being given in a subsequent part of this announcement.

Entertainment and Sports

It is planned to have an informal dance and reception Monday evening. The annual golf tournament for the J. B. Fisken cup, Thursday, with an informal banquet at the Country Club that evening, is a major feature of the entertainment and sports which are being arranged by C. W. Fick and R. J. Cobban, respective chairmen of the Entertainment and Sports Committees. Effort is being made to secure for the golf tournament, the course of the Portland Golf Club—one of the finest among Portland's many excellent courses; and the ample facilities afforded by the new club house at this course will make an excellent setting for the informal banquet and dance the evening of the tournament.

Mrs. A. S. Moody, Chairman of the Ladies Entertainment Committee, is making arrangements which will keep the visiting ladies agreeably occupied at luncheons, teas, and bridge parties, at a number of the many beauty spots in and around Portland.

Inspection Trips

Trips of diverse interest are being planned by E. F. Pearson. Chief among these will be one to the Oak Grove Development of the Pacific Northwest Public Service Company on the Clackamas River, where a second generating unit is being installed; and another to the Northwestern Electric Company's hydroelectric development on the Lewis River, where dam construction will be seen in full swing.

Convention Subcommittees

The following have been selected from the General Convention Committee to handle the various activities in connection with the Convention: Program, H. H. Cake; Golf, R. J. Cobban; Entertainment, C. W. Fick; Finance, A. S. Moody; Hotel, A. K. Morehouse; Transportation, C. P. Osborne; Publicity, Berkeley Snow; Reception, J. E. Yates; Registration, A. H. Kreul; Trips, E. F. Pearson; Ladies Entertainment, Mrs. A. S. Moody.

Following is a tentative list of the papers which are scheduled for presentation at the technical sessions.

Communication

The Communication System of the Southern California Edison Company, Ltd., R. B. Ashbrook and F. B. Doolittle, Southern California Edison Co., Ltd.

Commercial Aircraft Radiophone Communication, R. H. Freeman, Boeing Air Transport, Inc.

Harmonic Generation by Means of Grid Circuit Distortion, F. E. Terman and E. H. Fisher, Stanford University and D. E. Chambers, General Electric Co.

Power Stations

Relay Developments, E. R. Stauffacher, Southern California Edison Co.

Steam Power Development of the Pacific Gas & Electric Co., R. C. Powell, Pacific Gas and Electric Co.

Mercury Arc Rectifiers, O. K. Marti, American Brown Boveri Co., Inc.

Grounding Banks of Transformers with Neutral Impedance and the Resultant Transient Conditions in the Windings, F. J. Vogel and J. K. Hodnette, Westinghouse Electric & Mfg. Co.

Transmission and Distribution

The Mechanical Performance of Oil Circuit Breakers, A. E. Swaeger, Pacific Electric Mfg. Co.

Economic Characteristics of Hollow Core Cable Characteristics at Shuffleton Steam Plant of Puget Sound Power & Light Company, L. N. Robinson, Stone & Webster.

Corona Tests at Stanford, J. S. Carroll, Stanford University

Influence of Polarity on High-Voltage Discharges, F. O. McMillan and E. C. Starr, Oregon State College

Insulator Designs and Studies in Cement and Porcelain, K. A. Hawley, Locke Insulator Corp.

Wood Arms on Steel Structures, A. O. Austin, Ohio Insulator Co.

Critique of Ground Wire Theory, L. V. Bewley, General Electric Co.

Research and Development

Forecasting Precipitation, A. F. Gorton, Scripps Institute of Oceanography

An Electric China Firing Kiln, George S. Smith, University of Washington

Pennsylvania Electrification, J. V. B. Duer, Pennsylvania Railroad Co.

Electricity's Part in Copper Production, R. J. Corfield, Utah Copper Company

Election of A. I. E. E. Officers

William States Lee, Consulting Engineer, President of the W. S. Lee Engineering Corporation, Charlotte, N. C., was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1930, as announced at the Annual Meeting of the Institute held at Toronto, Ontario, June 23, during the Annual Summer Convention of the Institute. The other officers elected were: Vice-Presidents I. E. Moultrop, Chief Engineer, Edison Elec. Illuminating Co., Boston, Mass.; H. P. Charlesworth, Vice-President, Bell Telephone Laboratories, New York, N. Y., T. N. Lacy, Chief Engineer, Michigan Bell Telephone Company, Detroit, Mich.; George C. Shaad, Dean, School of Engineering and Architecture, University of Kansas, Lawrence, Kans.; H. V. Carpenter, Dean of Mechanic Arts and Engineering, State College, Pullman, Wash.—Directors A. B. Cooper, General Manager, Ferranti Electric Limited, Toronto, Ont.; A. E. Knowlton, Associate Editor, *Electrical World*, New York, N. Y.; R. H. Tapscott, Electrical Engineer, New York Edison Company, New York, N. Y.—National Treasurer George A. Hamilton, Elizabeth, N. J. (reelected).

These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: Harold B. Smith (retiring President), Worcester, Mass.; R. F. Schuchardt, Chicago, Ill.; Herbert S. Evans, Boulder, Colo.; W. S. Rodman, Charlottesville, Va.; C. E. Fleager, San Francisco, Calif.; E. C. Stone, Pittsburgh, Pa.; C. E. Sisson, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; H. P. Liversidge, Philadelphia, Pa.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; A. E. Bettis, Kansas City, Mo.; J. E. Kearns, Chicago, Ill.; C. E. Stephens, New York, N. Y.

William S. Lee

Mr. Lee is a native of Lancaster, South Carolina. In 1894 the degree of C. E. was bestowed upon him by The Citadel, a military college in South Carolina, and in 1929 he received an honorary degree of Doctor of Science from Davidson College, North Carolina. His preliminary engineering experience was followed in 1897 by service as Resident Engineer at the Anderson (S. C.) Light and Power Company. In 1898 he became Resident Engineer of the Columbus Power Company, Georgia, of which he was made Chief Engineer in March 1902. One year later he was appointed Chief Engineer of the Catawba Power Company, Charlotte, N. C., becoming Vice-President and Chief Engineer in October 1903. This company is a subsidiary of the Southern Power Company, of which he became Chief Engineer in 1905, soon to be made Vice-President and Chief Engineer, a position which he filled with marked ability for the past fifteen years.

Among Mr. Lee's other affiliations, the following are outstanding: The W. S. Lee Engineering Corporation, as its President; President and Chief Engineer of the Piedmont and Northern Railway Company; Vice-President, Chief Engineer, and Director, Duke Power Company, Wateree Power Company, Western Carolina Power Company, Catawba Manufacturing and Electric Power Company; Director, American Cyanamid Company; and Vice-Chairman and Trustee of the Duke Endowment. He is also engaged in practise as a Consulting Engineer with offices in New York City and Charlotte, N. C.

He has been a pioneer in high-voltage hydroelectric power development and transmission, and is inventor of the Lee Pin.

His Institute activities are as follows: Associate 1904, Member 1907, Fellow 1913, Director 1911-14 and 1929-; a member for several years of the Committee on Power Transmission and Distribution, Standards Committee, and Committee on Power Generation, being at present a member of the latter two and of the Edison Medal Committee.

Mr. Lee's other professional memberships include the American Society of Mechanical Engineers, American Society of Civil Engineers, Engineering Institute of Canada, American Electrochemical Society, and the American Engineering Council.

Edison Honored by Argentine

A gold medal typifying the gratitude of electrical engineers and scientists of Argentine and their affection, for Thomas Alva Edison, as well as commemorative of the Golden Jubilee of his incandescent lamp, was presented to Mr. Edison on June 20, at his East Orange laboratory, by William A. Reece of Buenos Aires, President of General Electric, S. A., of Argentine, who acted as the representative of the Argentine Association of Electro-Technicians. C. C. Chesney, Vice-President of the General Electric Company of this country and a Past-President of the American Institute of Electrical Engineers, presided at the meeting at which presentation was made.

The medal, executed by Oliva Navarro, well-known Argentine sculptor, was awarded by the technical society last Fall when South America joined with the world in celebrating the 50th birthday of Mr. Edison's lamp. In presenting the medal, Mr. Reece handed Mr. Edison a letter signed by N. Besio Moreno, President of the society, explaining the award. The latter is quoted in part as follows:

Mr. Thomas Alva Edison. Buenos Aires, April 2, 1930.
Master:

The Argentine Association of Electro-Technicians, has deemed that the 21st day of October, 1879, has been most worthy of remembrance in our times because of benefits derived therefrom by humanity. It has likewise deemed that the work of the noted scientific investigator, who on that day gave us the invention of the electric incandescent lamp, as well as his whole life, has been a masterly model for the youth of Argentina.

On account of these considerations, the Association decided to celebrate with numerous commemorative events, the 21st day of October 1929. Among these events, which have extended throughout the territory of the Argentine Republic, there was included the presentation to you, dear Master, of a gold medal, as a testimony of the veneration, gratitude, and affection of the Argentine Association of Electro-Technicians and of the "Committee of Homage to Thomas Alva Edison," expressly appointed by the former, as well as of all Argentine electrical engineers, both native and resident, which our institution comprises.

We have asked our distinguished member on several occasions President of this association—the engineer William Asher Reece—to be good enough to deliver to you personally the gold medal which we dedicate to you, and to convey to you verbally our sentiments of admiration and attachment toward you, whose long existence and fruitful scientific activity we hope will continue for the benefit of the people and the general culture of all the men of the earth.

Engineer Reece, member of our Committee of Homage, has accepted the honorable mission with which we have entrusted him and he will call at your home to convey to you our devotion and esteem as a very slight compensation for all the benefits which every one of us has personally received from the work of your scientific spirit and your tireless industry, sign of a will invariably consecrated to the service of the highest general interests.

You may rest assured, dear Master, of the friendship and constant admiration of your Argentinean friends in whose name we speak.

(Signed) N. Besio Moreno
President

Mr. Edison in acknowledgment of the honor conferred upon him, replied:

"It is indeed very gratifying to be held in such high esteem as that which has prompted my well-wishers and coworkers of the Argentine Association of Electro-Technicians to dedicate to me the gold medal which has just been presented to me in their behalf and in behalf of the Committeee of Homage. I greatly appreciate the distinctive honor thus conferred upon me, and extend my sincere thanks to my friends in the Argentine for this token of their friendship."

Architectural Course for Illuminating Engineers

Beginning Monday, September 8, courses will be held under the auspices of Columbia University, covering the various departments of architecture for illuminating engineers. These courses will continue with on an average of five sessions a day through Friday September 12th, the respective dates including the treatment of topics as follows: September 8—How the Architect Designs; Ancient, Greek and Roman Architecture; a talk by a prominent architect; (trip to Metropolitan Museum of Art and then to modern buildings reflecting Greek and Roman styles): September 9—Demonstration of architectural designing (Edgar I. Williams, Architect and critic of design in the School of Architecture); Medieval, Byzantine, Romanesque, Gothic and Modern Architecture; September 10—Underlying Principles of Good Architectural Composition; Renaissance Architecture and Modern Adaptations: September 11—How Architectural Composition Should Control Everything, Modern Architecture; and September 12—The Architects' Vocabulary; The Architects' Relation to a Building Project.

This course of Fundamentals of Architecture was organized, and is sponsored, by the Illuminating Engineering Society. The lectures will be held under the auspices of the School of Architecture, Columbia University, with classes at the Architectural League Club House, 115 East 40th St., New York, N. Y. The fee for the entire course including transportation for inspection trips is $25.00. Application should be made to Professor H. Vandervoort Walsh, School of Architecture, Columbia University, New York, N. Y.

The National Hydraulic Laboratory Bill is Signed

After seven years of effort by the engineering profession, Congress has passed the bill providing for a National Hydraulic Research Laboratory in the Bureau of Standards, Washington, D. C.

This instructs that there be appropriated out of any money in the Treasury not otherwise disbursed and not to exceed $350,000, "moneys to be expended by the Secretary of Commerce for the construction and installation, upon the present site of the Bureau of Standards in the District of Columbia, of a suitable hydraulic laboratory building and such equipment, utilities, and appurtenances thereto as may be necessary."

The idea of a National Hydraulic Research Laboratory was first proposed by Mr. John R. Freeman in a presidential address before the American Society of Civil Engineers. Senator Joseph E. Ransdell of Louisiana had long cherished this same idea, and had in fact discussed the matter with officials of American Engineering Council, which was instrumental in bringing Mr. Freeman and Senator Ransdell together, working toward a realization of the project. The legislation was begun in the 67th Congress, September 8, 1922, when the question was officially brought to the attention of American Engineering Council, which endorsed the idea and has ever since given it continuous support. The bill was reintroduced in the 68th Congress 1923 and further hearings were held May 1924. It failed to pass the 69th Congress Feb. 16, 1926 but in the 70th Congress, Senator Ransdell introduced the measure as S. 1710, April 7, 1928 and the bill passed the Senate April 13, 1928, but after extensive hearings in the House before the Rivers and Harbors Committee, it failed to pass due to the strong opposition of General Edgar Jadwin then Chief of Engineers, U. S. A.

On January 6, 1930, in the 71st Congress, Senator Ransdell again presented his measure as S. 3043 and at his request Congressman James O'Connor introduced it in the House as H. R. 8299. S. 3043 passed the Senate on April 7, 1930. In the meantime, the O'Connor bill had passed the House with the cordial approval of General Lytle Brown, Chief of Engineers, U. S. A. However, the House measure contained some minor amendments and in order to expedite the matter, Senator Ransdell requested that the House bill be reported favorably by the Commerce Committee. This was agreed to with the slight change that the laboratory's use be extended to independent government agencies. The amended measure passed the Senate on May 7, 1930 and the House concurred in the amendments May 8, 1930. On May 14 President Hoover signed the bill he had supported ever since he was Secretary of Commerce.

So far as can be ascertained, this is the first measure to become a law which extends the functions of the Bureau of Standards in any way over that provided in the original enabling act. Director George K. Burgess is most anxious to have this new laboratory so equipped that it will exceed anything of its kind now in existence. To this end, he is requesting the formation of an Advisory Committee on the National Hydraulic Laboratory which will have representatives from the Corps of Engineers, War Department; Bureau of Public Roads, Department of Agriculture; Bureau of Reclamation, U. S. Geological Survey, Federal Power Commission, Interior Department; and Coast and Goedetic Survey, Department of Commerce.

He has also requested American Engineering Council to suggest several members on this Advisory Committee. The appropriation for the laboratory will be carried in the second deficiency bill which is now pending in Congress.

House Agriculture Committee Reports Favorably on Engineering Experiment Station

The proposal to give cooperative Federal aid to engineering experiment stations and land grant colleges has made considerable progress during the present session of Congress. In all, five bills have been introduced on this subject. Senator McNary introduced S. 696, Congressman Arentz, H. R. 7831 and Congressman Haugen, H. R. 9717. After extensive hearings and investigations, the best thought of all these bills was incorporated

in two measures, H. R. 11789 by Haugen and S. 4172 by McNary. These latter two bills, identical in substance, are the rallying points for the friends of this legislation.

The House bill was reported favorably by the Committee on Agriculture, April 22, Report No. 1259, and is now on the calendar in the House. The committee, however, has had the last calendar call it will probably have this session of Congress and efforts to obtain a special rule under which this measure may be considered have been unsuccessful, due to the crowded condition of the legislative calendar and the desire of Congress for early adjournment. It is believed that enactment of this measure in the next session of Congress is assured.

The pending bill proposes that the United States Government contribute $10,000 in 1932, $15,000 in 1933, $20,000 in 1934 and $25,000 for each fiscal year thereafter, to each state and territory in which an operating engineering experiment station is maintained by a land grant college. In the event a state is not maintaining an engineering experiment station, it is given three years in which to establish and organize one. It must also provide for every dollar contributed by the Federal Government at least three for like periods and purposes, exclusive of land, buildings, and equipment.

At its recent meeting the Administrative Board of Council gave careful and lengthy consideration to H. R. 11789 and voted to approve both measures and endeavor actively to secure their passage.

Jefferson Medal Inaugurated

Congressman A. J. Griffin has introduced H. R. 9755, a bill providing for a medal of honor and awards to Government employees for distinguished work in science. The bill authorizes the President of the United States to present, in the name of Congress, a medal of honor and written testimonial to scientific workers whose labors have contributed to the advancement of scientific knowledge or applied its truths in a practical way for the welfare of the human race. The medal is to be known as Jefferson Medal of Honor for Distinguished Work in Science.

Recommendations to the President of persons to be considered for the honor contemplated in this act shall be made by a commission of three persons, consisting of one representative each from the National Academy of Sciences, the American Association for the Advancement of Sciences and American Engineering Council.

The bill further provides that not more than five scientific workers shall receive the medal in any one year and that persons so honored shall receive the sum of $100 on the presentation of the medal and the testimonial; and thereafter, annually for life, a sum of money the amount of which shall be fixed by the commission making the award, said sum to be not less than $100 and not more than $500 per annum, exclusive of salary or pension.

The Administrative Board of American Engineering Council considered and approved in principle this bill but suggested that the number of recipients of the medal per annum be reduced to two.

American Engineering Council

SPRING MEETING OF ADMINISTRATIVE BOARD OF A. E. C.

The spring meeting of the Administrative Board was held May 12-13 in Washington, D. C. Twenty-eight of the thirty members of the Board attended. Those present were: L. P. Alford, Farley Osgood, William Boss, H. S. Crocker, J. S. Dodds, A. J. Dyer, C. E. Grunsky, F. M. Gunby, John Lyle Harrington, H. E. Howe, Dexter S. Kimball, O. H. Koch, A. A. Krieger, J. H. Lawrence, R. C. Marshall, Jr., Anson Marston, B. A. Parks, O. P. Hood, George A. Reed, R. F. Schuchardt, C. F. Scott, C. E. Skinner, L. B. Stillwell, E. N. Trump, Edwin F. Wendt, G. S. Williams and D. Robert Yarnall.

Reforestation Report. The Committee on Reforestation gave consideration to the following:

H. R. 3245—Englebright—Authorizing appropriations for the construction and maintenance of improvements necessary for protection of national forests from fire. Recommendation: Complete support of measure.

H. R. 6981—Nolan—To promote the better protection and highest public use of the lands of the United States and adjacent lands and waters in Northern Minnesota. Recommendation: Support.

S. 3487—A bill to provide for the acceptance of a donation of land and the construction thereon of suitable buildings and appurtenances for the forest products laboratory. Recommendation: No Action.

H. R. 10877—Authorizing appropriations to be expended under the provisions of sections 4 to 14 of the Act of March 1, 1911, entitled: "An Act to enable any state to cooperate with any other state or states or with the United States, for the protection of the water-sheds of navigable streams and to appoint a commission for the acquisition of lands for the purpose of conserving the navigability of navigable rivers," as amended. Recommendation: That the bill be supported.

S. 3531—A bill authorizing the Secretary of Agriculture to enlarge tree planting operations on national forests east of the Rocky Mountains. Recommendation: Full support of measure.

The committee's report and its recommendations were in each case approved.

U. S. Weather Bureau. Many suggestions whereby the Weather Bureau might improve its services to engineers have been recently received by American Engineering Council. After careful consideration the Executive Committee recommended and the Administrative Board authorized President Grunsky to appoint a committee of three to confer with officials of the Weather Bureau to determine the directions in which the Bureau may make its work more useful to engineers. Mr. Mr. Grunsky has now under consideration the selection of the personnel of this committee.

Technological Employment. The subject of technological employment was ably presented before the Administrative Board in Executive Session by Dean Dexter S. Kimball. The Board also had before it the three Wagner bills which deal with the general subject of unemployment.

The first of these, S. 3059, is a prosperity reserve measure to which Council gave its support. S. 3060 providing for national cooperative aid to state employment agencies and S. 3061 providing for the extension of enemployment statistics, were not acted upon because they were thought to be without the purview of American Engineering Council.

RECLAMATION BUREAU INITIATES STUDY OF CRACKING OF DAMS

The Bureau of Reclamation under the directorship of Doctor Elwood Mead, has initiated a study of cracks in dams. A comprehensive study of this subject was recommended by the Boulder Dam Consulting Board and R. F. Walter, Chief Engineer of the Bureau, has selected Professor H. M. Westergaard to take charge of the work. Professor Westergaard is now visiting dams in this country which seem to offer the best sources of information upon this subject. It is believed that this work will be extremely helpful in furthering the technical knowledge on the subject of safety of dam construction.

WASHINGTON SOCIETY ENTERTAINS GRUNSKY

On Monday evening, May 12, at Chevy Chase Country Club, the Washington Society of Engineers gave a dinner in honor of President C. E. Grunsky. The speakers of the evening were Mr. E. W. James and Mr. Grunsky. The toastmaster was the president of the Washington Society, Mr. F. A. Hunnewell.

FLOOD CONTROL COMMITTEE TO CONSIDER LEGISLATION

The Flood Control Committee of American Engineering Council composed of Gardner S. Williams, Chairman, Baxter L.

Brown, John R. Freeman, Arthur E. Morgan, John F. Stevens and John F. Coleman, recently had before it for consideration the following legislation:

S. 4145—Senator Hawes—To amend the Mississippi Flood Control Act by providing compensation for lands taken; S 4277—Hawes and Patterson—Providing for action in District Courts. The committee felt that these two bills changed nothing so far as the engineering features of the Mississippi flood control plan were concerned and might involve the nation in unknown expenditures. It therefore recommended that no action be taken concerning them; recommendation was approved by the Administrative Board on May 12.

The committee considered also H. R. 9376 by Representative Sears which provides for a Federal Board of Public Works to take charge of the run-off and flood waters between the Allegheny and Rocky Mountain systems; H. R. 11732 by Representative Stone, providing a Federal Flood Control Board, members to be appointed by the President: and H. R. 9848 by Representative O'Connor, to create a waterways and water resources commission.

The committee recommended and the Administrative Bardo approved that these three bills be referred to the Committee on Water Resources and Control for further study and report. This committee is composed of W. S. Conant, Chairman, W. S. Lee, A. E. Morgan, Farley Osgood, and G. S. Williams.

A limited number of reprints from *Engineering News-Record* are available, giving the Federal and State agencies dealing with water resources and showing on the subjects of navigation, water power, irrigation, drainage, flood control, stream pollution and dams, what agencies in Federal and State governments have investigatory, regulatory, supervisory, and construction control over these several subjects.

PERSONAL MENTION

A. R. Nissar has been appointed Principal of the Calcutta Technical School, Calcutta, India.

A. C. Kirkwood, in February of this year became a member of the Engineering Staff of the Burns & McDonnell Engineering Company of Kansas City and Los Angeles.

Archibald Page, Chief Engineer and Manager of the Central Electricity Board, London, England, was created Knight in January 1930 and is now Sir Archibald Page.

Frances H. Pettee, Southeastern District Manager of the Simplex Wire & Cable Company with offices at Jacksonville, Fla., was, on June 15th, transferred to the head office in Boston.

George J. Eltz, Jr. is now Vice-President of the Continental Radio Corporation, distributors of Radio Corporation sets and products, Hartford, Conn.

Edward B. Newill, who last October became Vice-President in Charge of Engineering for the General Motors Radio Corporation, has just been appointed Vice-President of the Frigidaire Corporation in Charge of Engineering.

H. A. Dodge, for ten years with the United States Rubber Company as Electrical Engineer, resigned as of July 1, 1930, to accept a position in the same capacity with S. H. Kress & Co., New York, N. Y.

J. B. Leinbach has completed a research schedule in High-Frequency Radio Transmission and Reception and is now employed by the Public Service Electric & Gas Co., as Laboratory Assistant at the Testing Laboratory in Irvington, N. J.

W. E. Bostwick, Associate, formerly of the office of the Electrical Engineer, Pennsylvania Railroad has been promoted to Inspector and transferred to the Test Department of the same company.

W. M. Hoen, Chief Electrical-Mechanical Engineer for Oglebay Norton & Company, with headquarters at Ironwood, Michigan, is leaving for Moscow, Russia, where he will have charge of the company's Electrical-Mechanical Department and interests on their Russian contract.

Cecil B. Dake, on April 15th last, resigned from the position of Distribution Engineer for the Oswegatchie Light & Power Co. of Gouverneur, N. Y. to accept office at Ogdensburg, N. Y., as Assistant Manager of the St. Lawrence County Utilities, Inc. now part of the Niagara Hudson Power Corporation.

Ira W. Fisk and Edward A. Roberts, partners of the law firm of Fisk & Roberts, have been retained by the State of New Jersey Public Service Commission to appraise the bus equipment of the Public Service Coordinated Transport of New Jersey. This company operated approximately twenty-three hundred busses and is one of the largest in the United States.

L. W. Chubb, former Manager of the Radio Engineering Department of the Westinghouse Electric & Manufacturing Company, returned to the company recently as Director of the Westinghouse Research Laboratories. The announcement of his return was made by R. S. Feicht, Director of Engineering. Mr. Chubb has been a Fellow of the Institute since 1921.

Edward Kerschner has been advanced to the position of Vice-President of Standard Underground Cable Co. Division of General Cable Corporation with headquarters at Perth Amboy, N. J. Mr. Kerschner was formerly District Manager of Chicago office for both Standard Underground Cable Co. and General Cable Corporation.

Albert A. Schuhler, who since 1923 has been engaged in sales engineering for the Holtzer-Cabot Electric Company with headquarters at St. Louis and Kansas City, Missouri, resigned his position and became Assistant Sales Manager for the Connecticut Telephone and Electric Corporation, Signal Systems Division at Meriden, Connecticut, where his duties will include the development and sales of signal equipment.

Lewis M. Clement recently appointed Assistant to the Manager of the Radio Department of the Westinghouse Electric and Manufacturing Company, heads the engineering activities of the Radio Department, being in charge of the design, inspection, and service of the Westinghouse Radio. He entered the employ of the Marconi Company as Assistant Engineer in charge of high power stations in 1914.

Stewart N. Clarkson has resigned as Assistant Director of the National Electrical Manufacturers Association, to establish offices at 522 Fifth Avenue, New York. Mr. Clarkson functioned in a similar capacity as Executive Secretary of the Electric Power Club for five years and for the Products Sections of the National Electrical Manufacturers Association since its formation in 1926. He is Chairman of the St. Louis Section of the American Institute of Electrical Engineers.

J. R. Ramsey has been appointed General Manager of the Eastern New York Group with headquarters at Mechanicsville. This group comprises the Harlem Valley, Mechanicsville and Plattsburgh Divisions covering an area along the Hudson River from Westchester County to Canada. Previously, Mr. Ramsey was General Manager of the Western New York Division of the Rochester Group of the Associated Gas & Electric System, with headquarters at Lancaster, N. Y.

N. H. Coit, formerly General Manager of the Florida Public Service Company, and for the past nine months General Manager of the Broad River Power Company, a subsidiary of the General Gas & Electric Corporation and a part of the Associated Gas & Electric System, has been elected Vice-President of the Broad River Power Company, with headquarters in Columbia, S. C. He will now be Vice-President and General Manager. Mr. Coit is also Vice-President of the Lexington Water Power Company for which W. S. Barstow & Company, Inc., is now

building the largest earthen dam in the world for hydroelectric development on the Saluda river, 14 miles from Columbia.

Cummings C. Chesney, Past-President of the Institute, Vice-President of the General Elec. Co. and Chairman of its Manufacturing Committee, will be relieved on July 1st at his own request, and will be succeeded by Vice-President William R. Burrows.

Mr. Chesney is a pioneer in the electrical industry, having been associated in early life with the late William Stanley, who developed the transformer; Mr. Burrows, with Mr. John W. Howell, achieved important work in improving the methods of lamp manufacturing, a number of material contributions being made by Mr. Burrows. These developments comprised principally the first stem machine, carbon filament treating machine, tubulating machine, automatic lead-wire welding machine, combination stem and flare machine, rotary clamping machine for mounting carbon filaments, and automatic exhaust machine.

Edwin Jay Prindle, of 111 Broadway, Chairman of the Patents Committee of the American Engineering Council, a leader of movements which resulted in the reform of the U. S. Patent Office and in the increase of salaries to members of the Federal Judiciary, received the honorary degree of Doctor of Laws from the National University, Washington, D. C. on June 13. He received his Bachelor's Degree in Law from the National University Law School in 1892 and his Master's Degree in 1894. Mr. Prindle joined the Institute in 1906.

In addition to his representation of the American Engineering Council, Mr. Prindle is a member of the Committees on Patents of the Bar Association of New York City, and of the New York County Lawyers Association, Chairman of the Patents Committees of the National Association of Manufacturers, the National Research Council. and the American Electro-Chemical Society.

Obituary

Elmer Ambrose Sperry, famous inventor and a Charter Member of the Institute, died in St. John's Hospital, Brooklyn, New York, the morning of June 16th, death coming as the result of complications which set in after he had practically recovered from an operation previously performed.

He was born at Cortland, New York, October 12, 1860. From the age of thirteen, when he made his first wooden turbine water-wheel, his life was one long experiment in the application of natural laws to physical things, and up to the very end of his life, his inventive genius was outstanding. He had to his credit nearly four hundred patents. He passed through the State Normal School at Cortland, also attending lectures at Cornell University, later becoming a regular student at the University for the term 1879-1881. From 1880 to 1884 his principal work was experimentation and development of arc lighting, producing the independent feed lamp, the automatic current regulators, and somewhat later, perfecting of the reactionary effect between armature and field allowing the rotating of brushes, thus controlling the e. m. f. at first through a small range which was increased to a total range of 0 volts to 3600 volts on the 60 arc light machine "without the least evidence of sparking." This was during the period from 1884 to 1888. Prior to 1910, six industrial corporations had been founded to manufacture his inventions with an aggregate annual business of over five millions of dollars. He was inventor of the first electric mining machinery, and many new developments in the transportational line. In the early nineties he patented a storage battery, and with it designed an electric automobile which ran the remarkable distance of 100 miles. It was he who drive the first American-made automobile through the streets of Paris. He invented the Sperry searchlight, so powerful that a newspaper thirty miles distant could be read by its rays. This was a successive to a beacon which he erected on Lake Michigan in 1883, which was known as the highest electric beacon in the world. His gyro-compass cannot be deflected from the true north. It was completed in 1910 and was first tried out on the United States battleship *Delaware* at the New York Navy Yard, Brooklyn. Soon after this the United States Navy adopted it and during the war, it was used in the Allied navy and subsequently by more than sixty steamship lines. In 1913 the gyroscopic stabilizer for ships appeared. The following year Mr. Sperry entered the field of aeronautics, and on June 14, 1914, his airplane stabilizer was awarded a first prize of 50,000 francs by the French government in a contest for safety devices for airplanes. The winning machine was piloted by the inventor's son, Lawrence B. Sperry, afterward killed in an airplane accident. In 1915 Mr. Sperry was appointed a member of the newly created Naval Advisory Board, and during the war contributed many inventions to aerial and maritime development. The high-powered searchlight mentioned above was an important factor in the defense of Paris and London. One of the most important of Mr. Sperry's inventions was the high-intensity arc light, which has been used for various automatic searchlights and night-flying airplanes. One of these lights has developed 1½ billion candlepower. It is called the "Sunlight" arc and has found extensive use in the motion picture industry. More the exception than the rule, Mr. Sperry always coupled sound business ability with his inventive genius. In 1910 when he organized his own company, The Sperry Gyroscope Company, he had already turned over to others numerous companies which he had founded in earlier years. As President and Chairman of the Board of Managers of his own company, he built and operated an extensive manufacturing plant and experimental laboratory at Manhattan Bridge Plaza, Brooklyn. The Sperry Development Corporation was established for the experimental work. In 1929 the parent company was sold to the Curtiss air interests. Last year when Professor Albert Michelson conducted his experiments at Mount Wilson for a more accurate determination of the speed of light, the Sperry superpower searchlight was one of the essential instruments used. Mr. Sperry himself financed the cost of apparatus necessary for these experiments. The Sperry Rail Service Corporation was one of Mr. Sperry's developments. During the past year, as a successor to it and the Sperry Development Company, Inc., he had organized the Sperry Products, Inc. Mr. Sperry was a charter member also of the Electro-Chemical Society. Other organizations in which he held membership were The American Association for the Advancement of Science, the American Physical Society, The American Society of Mechanical Engineers, the Naval Architects and Marine Engineers, New York Electrical Society, American Petroleum Institute, Edison Pioneers, National Aeronautical Association, Aero Club of America, Engineers Club (New York), the National Electric Light Association, Franklin Institute, and Japan Society. He was a Director of the Museum of Peaceful Arts also.

Two medals have been awarded him (one in 1914 and the other in 1929) by the Franklin Institute; he received the Collier Trophies 1915, 1916; the Holley Medal in 1927; the John Fritz Medal in 1927; the Albert Gary Medal in 1929; he was twice decorated by the Czar of Russia; twice by the Emperor of Japan (Order of the Rising Sun and Order of the Sacred Treasure). He also received the Grand prize of the Panama Exposition. The honorary degree of Doctor of Engineering was conferred upon him by Stevens Institute and Doctor of Science by Northwestern University. High tribute has been paid Mr. Sperry by Secretary Adams in citing service rendered by him to the United States Navy; Mr. Edison commented upon the "energy in industry, great resourcefulness and capacity" with which Mr. Sperry did all things. E. W. Rice, Jr. says of him "His contributions both electrical or mechanical are well known throughout the world. He combined charm of personality with an inexhaustible supply of optiminism, perseverance, industry, and enthusiasm which inspired and stimulated to greater endeavor all with whom he came in contact." It was Mr. Sperry who was

largely instrumental in the gratifying completion of plans for the first World Engineering Congress so recently and successfully held at Tokyo, Japan last year. Science's memory of him is his monument.

Andrew Lawrence Riker, Consulting Engineer, inventor, and one of the pioneers in the development of automobiles in this country, died suddenly at his home in Bridgeport, Connecticut, June 1, 1930.

He was a native of New York City, born October 22, 1868; in 1882 he took up the subject of electricity experimentally and in 1887, as a manufacturer of electrical apparatus, designed and patented many electrical devices. This was the year he joined the Institute, first as an Associate, transferred to Member in 1895. Motors and batteries were his special interests. When only 16 he designed and built an electrically propelled tricycle, and in 1895 he produced his own four-wheeled electric motor car. In 1902 he brought out a car using the gasoline fuel and the Vanderbilt Cup race for 1908 was won by a car of his design running sixty-four and a half miles an hour. In a statement March 1929 emphasizing the importance of speed tests, Ernest N. Smith, General Manager of the American Automobile Association, coupled Mr. Riker's name with Henry Ford, Alexander Winton and Charles Duryea as "pioneers in the automobile industry who had staked their lives in tests for the development of speed." His world record of speed for the electric car, 63 seconds for a mile, established in 1899 on Long Island, was held for a duration of ten years. When 20 years old, Mr. Riker became President of the Riker Electric Motor Company, introducing the first toothed electric armature. Some of the early models served on the delivery route of B. Altman & Company for seventeen years or more, and as early as 1900, a Riker five-ton truck was surprising New Yorkers in the streets. In 1902 he joined the Locomobile Company of America, becoming Vice-President and Chief Engineer of this organization just as they were about to abandon the popular priced steam cars for one with gasoline fuel. Many of the features which he introduced into the new gasoline cars produced at that time have remained to be used in the present day models. In 1915 he was appointed to the Naval Consulting Board and became Chairman of its Committee on Internal Combustion Motors. He was the first President of the Society of Automobile Engineers, was a member of The American Society of Mechanical Engineers, the Automobile Club of America, the Engineers Club (New York), the Aero Club, and the Society of Mayflower Descendants.

William Henry Bristol, inventor of a phone to synchronize sound and action and a pioneer in the field of recording instruments, died June 18th at the New Haven Hospital. He was 70 years old and had been suffering for several months from a clot of blood which formed in the region of his heart. His present home was in Waterbury, Connecticut, where he was also born. His conception of an instrument to simultaneously record sound and action came in 1915, and the invention of the Bristol phone which is used to synchronize both in moving pictures, followed. Professor Bristol spent nearly a million dollars to perfect this instrument, a fully equipped motion picture laboratory and studio being erected in Waterbury for this purpose. Other instruments of his invention were for recording the measurement of pressure, temperature, electricity, speed and time.

He was graduated from Stevens Institute in 1884 with a degree in Mechanical Engineering. While still a student, he organized and taught the manual training department of the Workingman's School of New York. After graduation, he was appointed Instructor in Mathematics at Stevens, and later became Professor.

In 1899, Professor Bristol founded the Bristol Company at Waterbury, Conn. for the manufacture of his own inventions of recording instruments, for which he held many medals of award from numerous expositions; among these the John Scott Legacy medal bestowed by Franklin Institute at Philadelphia in 1890. He also received a medal of honor from the sesquicentenntial held at Philadelphia four years ago. Other awards were a medal and diploma at the Chicago Exposition in 1893, a silver medal at the Paris Exposition in 1900, a gold medal at the St. Louis Exposition in 1904 and a grand prize at the Panama Pacific International Exposition in 1915.

He was a member of many engineering societies, a Fellow of the American Association for the Advancement of Science and a Member of the Institute since 1907, having joined the year previous as an Associate.

W. S. Franklin, former Physicist at M. I. T. and a specialist on alternating-current work, died from injuries sustained in an automobile accident which occurred while he was driving north from Florida. Doctor Franklin was born in Kansas and graduated from the University of Kansas in 1887 with the degree of Bachelor of Science; one year later he received his Master of Science degree. From 1892 to 1897 he was Professor of Physics at the Iowa State University. In 1901 he received his Doctor of Science degree from Cornell. He went to Lehigh University in 1897 as Professor of Physics on Electrical Engineering, and resigned in 1915 to take up similar work at the Massachusetts Institute of Technology. Last year he resigned this professorship to go to Florida at the request of President Holt of Rollins College, Winter Park, Fla., where he was Visiting Professor in Physics. Last year his plan to curb Florida hurricanes, namely, that if "a ton or more of gunpowder were set off in a series of gigantic steel cones 100 ft. high and 50 ft. in diameter, the explosion would shoot up a rising column of warm air causing a small storm to break over each cone and thus disseminate energy which in concentrated form would become a menace,"—caused quite a sensation.

Doctor Franklin was an honorary member of the Kansas American Association for the Advancement of Science, Past-Chairman of its Physics Section, a member of the American Physical Society, and a past member of the Institute.

Miles Wren Birkett, Vice-President and General Manager of the Washington Water Power Company, Spokane, Washington, and only last month elected President of the Northwest Electric Light and Power Association, died June 13, after an operation for appendicitis.

He was born in Oawatonna, Minn., July 28, 1884. After graduating from the University of Wisconsin with the degree of B. S. in Electrical Engineering, he accepted a position in the Transmission Department of the Light and Power System of the Washington Water Power Company, Spokane, Washington. Two years later, in 1910 he was given the position of Assistant Superintendent of Light and Power under John B. Fisher, all 60,000-volt transmission lines and substations outside Spokane with the exception of the Railway substations coming under his jurisdiction both in matters of construction and operation. In 1922 he became General Manager of the company, and the following year he was elected Vice-President. Prior to his election to the predidency he had done much effective work for the Electric Light and Power Association. He joined the Institute in 1913 as an Associate and was transferred to the grade of Member in 1922.

Harold Wilson Wikle, Sales Engineer for the General Electric Company at Atlanta, Ga. and a member of the Institute's Atlanta Section, died April 24, 1930. Mr. Wikle joined the Institute as an Associate in 1924.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail, through the accuracy of our mailing records and the elimination of unnecessary expense for postage and clerical work.

Birdsall, W. T., 6 Vincent Place, Montclair, N. J.
Gorrissen, Chas., Hermanstrasse 38, Hamburg, Germany.
Hershey, H. E., Midwest Athletic Club, Madison St. & Hamlin Ave., Chicago, Ill.
Keegan, W. G., 767 Maple Ave., Los Angeles, Calif.
Kirkland, E. H., 6701 Cregier Ave., Chicago, Ill.
McDougall, D. J., 1501 W. Pierce St., Phoenix, Ariz.
Peirce, H. B., International Gen. Elec. Co., Schenectady, N. Y.
Quaas, Richard T., 545 W. 156 St., New York, N. Y.
Sachse, A. O., 87 Court St., Newark, N. J.
Schnake, H. C., 7 E. 42nd St., New York, N. Y.
Smedberg, O. L., 916 12th St., Oregon City, Ore.
Tsatsaron, Nicholas, Central Restaurant, 300 W. 40th St., New York, N. Y.

A. I. E. E. Section Activities

MEETING OF POWER GROUP CHICAGO SECTION

For the fifth and final 1929-30 meeting of the Power Group of the A. I. E. E., Chicago Section, held May 7, 1930, William A. Lindberg, Engineer of Electrical Distribution of the Commonwealth Edison Company, Chicago, presented a paper, *Distribution Practises.* This meeting was extremely well attended, as have been those preceding it, further verifying the fact that there is a permanent interest in such gatherings.

Mr. Lindberg demonstrated that the distribution system represents the electric utility's largest single item of investment. His able discussion of the subject disclosed the practise followed in the Chicago region, including the 4000-volt, four-wire system and the low-voltage d-c. network. He also told of plans for a low-voltage a-c. network. The large amount of underground cable required and the extreme variation in load densities made the Chicago system an excellent subject for discussion.

Following Mr. Lindberg's paper, C. A. Besse of the Byllesby Engineering and Management Corporation discussed the distribution system in use in Minneapolis. The methods being followed there differed quite materially from those of the Chicago system. This fact invited a very lively discussion during which both Mr. Lindberg and Mr. Besse were able to justify their respective systems in view of the difference in nature of the load at the two cities.

An Executive Committee consisting of R. D. Maxson, Public Service Company of Northern Illinois, Chairman; Mr. L. W. Smith, Sargent and Lundy; and N. C. Pearcy, Byllesby Engineering and Management Corporation; was unanimously elected to direct the activities of the Power Group for the coming fiscal year.

PHASE DISTORTION SUBJECT OF NEW YORK SECTION MEETING

At its meeting May 7, 1930, the New York Section of the Institute presented the three following papers on the effects of phase-distortion in telephone apparatus, and the measurement of such distortion:

Effects of Phase Distortion on Telephone Quality, by John C. Steainberg, Bell Telephone Laboratories, New York, N. Y.
Phase Distortion in Telephone Apparatus, by C. E. Lane, Bell Telephone Laboratories, New York, N. Y.
Measurement of Phase Distortion, by H. Nyquist and S. Brand, American Tel. & Tel. Company, New York, N. Y.

A very limited number of copies of these papers are on distribution from Institute headquarters should any of the members be interested in obtaining them.

SAN ANTONIO SECTION ORGANIZED

At the meeting held May 23, 1930, the formation of a Section of the Institute at San Antonio, Texas, was authorized by the Board of Directors. A tentative organization had previously been effected, and at a meeting held on May 26, the officers named below were introduced and officially took charge of the activities of the Section:

Dean W. Flowers, Chairman
Eugene Bissett, Secretary
J. E. Woods, Chairman, Meetings and Papers Committee
I. A. Uhr, Chairman, Entertainment Committee
George Forbes, Chairman, Membership and Attendance Committees

Following a dinner, Vice-President B. D. Hull outlined the history of the Institute and described its activities. Chairman Flowers gave a brief address on the benefits to be derived by the members of the new Section.

The principal address of the evening was given by L. T. Blaisdell, Southwestern District Manager, General Electric Company, Dallas, Texas, on the advancement of the electrical industry during the past fifty-five years.

The attendance was 45, and there were many expressions of appreciation of Mr. Blaisdell's address.

PAPERS BY YOUNGER MEMBERS OF SEATTLE SECTION

The annual meeting of the Seattle Section for the presentation of papers by members who had never presented papers at Section meetings was held on May 20, 1930, and the program was as follows:

Engineering the Distribution Substation, by Roy E. Wenk
Errors in Power Metering, by E. C. Goodale

The prize of \$25.00 was awarded to E. C. Goodale. The attendance was 50.

The Nominating Committee presented the names given below for Section officers for next year; and they were unanimously elected:

C. E. Carey, Chairman
Philip D. Jennings, Secretary-Treasurer.

ORGANIZATION OF MEMPHIS SECTION

At its meeting held on May 23, the Board of Directors authorized the formation of a Section of the Institute at Memphis, Tenn. This Section held an organization meeting on June 7th, at which the following officers were elected: M. Eldredge, Chairman; W. A. Gentry, Secretary; W. F. Bowld, Treasurer; W. A. Gentry being chosen as the delegate to represent the Section at the Summer Convention.

Prior to the authorization of the Section, a preliminary meeting was held on May 9, at which C. A. Powell of the Westinghouse Electric & Mfg. Company gave an interesting and instructive talk on the Development of Transmission Lines.

PAST SECTION MEETINGS

Akron

The Quest of the Unknown, by Professor Harold B. Smith, President of the Institute. Film—"Proven." Election of officers as follows: H. C. Paiste, Chairman; M. Berthold, Secretary; W. C. Secrest, Treasurer. May 16. Attendance 30.

Baltimore

The New High-Voltage Laboratory of the Locke Insulator Corp. at Baltimore, by H. A. Frey, Locke Insulator Corp. The

following officers elected: W. B. Kouwenhoven, Chairman; K. A. Hawley, Vice-Chairman; J. Wells, Secretary. May 9. Attendance 115.

Boston

The Quest of the Unknown, by Professor Harold B. Smith, President of the Institute. Joint meeting with other Sections in New England at Worcester Polytechnic Institute. Attendance from Boston Section 75.

Annual meeting. Election of officers as follows: J. P. Kobrock, Chairman; C. A. Corney, Vice-Chairman; G. J. Crowdes, Secretary-Treasurer. Entertainment followed. May 15. Attendance 232.

Cincinnati

W. D. Bearce, General Electric Co., reviewed the progress made in the electrification of railways throughout the world. Illustrated. Motion pictures were presented of the Great Northern Railway, Mexican Railway, and Cincinnati Street Railway Company's Automatic Railway Equipment. May 8. Attendance 35.

Cleveland

The Quest of the Unknown, by Professor Harold B. Smith, President of the Institute. Election of officers as follows: Frank W. Braund, Chairman; John M. Smith, Secretary-Treasurer. May 15. Attendance 95.

A Trip Through the Grand Canyon of the Colorado, by Julius F. Stone, Ohio State University. Election of officers as follows: C. D. Price, Chairman; A. F. Wilson, Secretary. Dinner preceded the meeting. May 23. Attendance 22.

Connecticut

Going by Air, by Parker Brooks Sturgis, Transcontinental Air Transport, Inc. Meeting held at the Hartford Electric Light Co. May 21. Attendance 38.

Dallas

WFAA, the New 50,000-Watt Superpower Radio Station, by L. F. Jones, General Electric Co. Election of officers as follows: L. T. Blaisdell, Chairman; G. A. Dyer, Secretary. May 19. Attendance 90.

Denver

Election of officers as follows: R. B. Bonney, Chairman; R. E. Nyswander, Vice-Chairman; N. R. Love, Secretary-Treasurer. May 22. Attendance 18.

The Marvels of Sound Transmission, by S. P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. May 28. Attendance 3600.

Detroit-Ann Arbor

The Quest of the Unknown, by Professor Harold B. Smith, President of the Institute. May 14. Attendance 150.

Electrical Developments in New York, by T. F. Barton, General Electric Co. Dinner preceded the meeting. May 20. Attendance 175.

Erie

Television—Its Fundamental Physical and Psychological Principles, by J. O. Perrine, American Tel. & Tel. Co. Election of officers as follows: G. R. McDonald, Chairman; G. I. LeBaron, Secretary. May 20. Attendance 225.

Houston

Lightning, by V. Y. Graham, General Electric Co. Election of officers as follows: C. D. Farman, Chairman; Hezzie Clark, Secretary. May 22. Attendance 30.

Iowa

Lightning and the Protection of Transmission Lines, by J. J. Torok, Westinghouse Elec. & Mfg. Co. Election of officers as follows: J. K. McNeely, Chairman; H. B. Hoffhaus, Secretary-Treasurer. May 14. Attendance 83.

Kansas City

Engineer's Relation to His Community, by Prof. Francis Ellis Johnson, University of Kansas. Election of officers as follows: Joe. S. Palmer, Chairman; Bruce E. Dolch, Secretary-Treasurer. May 19. Attendance 63.

Los Angeles

H. L. Doolittle and H. T. Crane, both of the Southern California Edison Company, gave talks on the construction and illuminating features of the new Edison building. May 15. Attendance 150.

Louisville

Election of officers as follows: James Clark, Jr., Chairman; Philip P. Ash, Secretary-Treasurer. May 20. Attendance 27.

Milwaukee

The Practical Application of Humor, by Professor W. C. Hewitt, Oshkosh Normal School. Election of officers as follows: F. A. Kartak, Chairman; I. L. Illing, Secretary-Treasurer. June 4.

Minnesota

Transoceanic Communication, by L. E. Whittemore, American Telephone & Telegraph Co. Election of officers as follows: D. K. Lewis, Chairman; Oscar Gaarden, Vice-Chairman; H. J. Pierce, Secretary-Treasurer. May 28. Attendance 200.

Niagara Frontier

Electric Drive for Ships, by Frank V. Smith, General Electric Co. Election of officers as follows: E. S. Bundy, Chairman; R. T. Henry, Vice-Chairman; G. W. Eighmy, Secretary. May 16. Attendance 85.

Oklahoma City

Joint meeting with the University of Oklahoma and Oklahoma A. & M. College Branches. Election of officers as follows: F. J. Meyer, Chairman; C. T. Almquist, Vice-Chairman; C. E. Bathe, Secretary-Treasurer. (For complete report see Student Activities Dept.)

Philadelphia

Electric Power Supply in the Philadelphia Area, by J. W. Anderson, Philadelphia Electric Co. May 12. Attendance 150.

Pittsburgh

Annual Dance. Election of officers as follows: C. T. Sinclair, Chairman; F. A. Connor, Secretary-Treasurer. Held jointly with the Engineers Society of Western Pennsylvania. May 13. Attendance 363.

Rochester

Recording and Reproducing Sound Pictures, by F. L. Hunt, Bell Telephone Laboratories, Inc. Election of officers as follows: Harvey J. Klumb, Chairman; John G. Garritt, Vice-Chairman; F. C. Young, Secretary-Treasurer. May 15. Attendance 481.

Sharon

Past, Present, and Future of Electricity, by C. M. Ripley, General Electric Co. May 13. Attendance 120.

Spokane

Some New Vacuum Tubes and Their Applications, by M. J. Poland, Student, Washington State College;

The Mercury Arc Rectifier Equipment at the Trail Electrolytic Zinc Plant, by Hugh Tinling. Joint meeting with the Washington State College and Idaho University Branches. April 25. Attendance 65.

Russia, by Joseph S. Thompson, The Pacific Electric Mfg. Corp. May 2. Attendance 54.

Election of officers as follows: Loren A. Traub, Chairman; H. L. Vincent, Vice-Chairman; C. F. Norberg, Secretary-Treasurer. May 23. Attendance 20.

Toledo

Annual banquet. Address by Hon. Mayor William T. Jackson. Election of officers as follows: F. H. Dubs, Chairman; Max Neuber, Secretary. Albert E. Buchenberg, Electric Auto-Lite Co., spoke on conditions in Russia. June 6. Attendance 41.

Toronto

Election of officers as follows: D. A. McKenzie, Chairman; G. D. Floyd, Secretary. May 9. Attendance 30.

Urbana

Election of officers as follows: C. E. Skroder, Chairman; W. J. Putnam, Secretary-Treasurer. May 23. Attendance 15.

Vancouver

Observatories and Their Work, by W. E. Harper, Dominion Astrophysical Observatory, Victoria, B. C. Illustrated. Members of the Engineering Institute of Canada invited. May 16. Attendance 47.

Washington

Electric Elevators, by Bassett Jones, Consulting Engineer. Illustrated. Election of officers as follows: George W. Vinal, Chairman; G. L. Weller, Vice-Chairman; J. L. Carr, Secretary-Treasurer. Dinner in honor of the speaker preceded the meeting. May 13. Attendance 29.

A. I. E. E. Student Activities

UTAH SECTION AND BRANCH MEETING

The Utah Section and the University of Utah Branch held their annual joint meeting for the presentation of a program by students at the Newhouse Hotel, Salt Lake City, May 26, 1930. After opening the meeting and making announcements, Chairman Kelm of the Section requested L. A. Moore, Chairman of the Branch, to preside, and the papers named below were presented by seniors:

Interference in Telephone Circuits, by Franklyn Shafer and Irving Alter

Earth Resistance, by Courtney Campbell and L. A. Moore

Radio Frequency Amplifiers, by Elmer P. Gertsh

Audio Frequency Amplifiers, by Owen deLange and Wayne Shaw

The attendance was 38, almost evenly divided between Students and Section members.

JOINT SECTION AND BRANCH MEETING IN OKLAHOMA

The annual joint meeting of the Okalhoma City Section and the Student Branches at the Oklahoma A. & M. College and the University of Oklahoma was held at the latter on May 16, 1930, opening at 10:00 a. m. with the following program:

Trend of Modern Circuit Breaker Design, by Walter Hoss, Oklahoma A. & M. College

Wave Propagation from an Electrodynamic Speaker, by Elden Peek, Oklahoma A. & N. College

Temperature Study of Piezoelectric Resonators, by Harold L. Pickens and Guy B. Sullaway, University of Oklahoma

History of Vacuum Tube Development, by J. Roscoe Duncan, Oklahoma A. & M. College

Temperature Study of Underground Transformer Vault, by E. E. Brady, C. W. Anthony, and J. H. Pernell, University of Oklahoma

Calculation of Constants of Actual Line from Electrical Constants of a Simulating Network, by Roy Nelson, Oklahoma A. & M. College

Television, by J. H. Watson, University of Oklahoma

Prizes of fifteen dollars, ten dollars, and five dollars were awarded as follows:

First—Elson Peek, Oklahoma A. & M. College

Second—Roy Nelson, Oklahoma A. & M. College

Third—J. Duncan, Oklahoma A. & M. College

L. S. Cook, an alumnus of the University of Oklahoma, now with the Western Union Telegraph Co., described and demonstrated a simplex telegraph printing machine.

A luncheon was held in the Faculty Club building, followed by an inspection trip through the new library and the engineering laboratories.

The meeting, attended by 60, was of great interest to all.

JOINT SECTION AND BRANCH MEETING IN OREGON

The Portland Section and the Oregon State College Branch held their second joint meeting of this year, for the presentation of papers by students, at the College on May 24, 1930. With B. G. Griffith, Chairman of the Branch, presiding, the following program was presented:

A Vacuum Tube Watt Meter, by George W. Barnes

Electrical Measurements of Mechanical Vibration, by C. A. McElmurry and K. Mahen

Visual Lichtenberg Figure Volt Meter, by Lowell Hollingsworth

The Corona Rectifier Utilizing the Space Charge Phenomenon Assisted with Corona for Producing Direct Current, by W. R. Bullis and C. C. Foster.

The attendance was 105, and included forty Section members. There was keen interest both in the papers and in the discussion which followed each.

During the afternoon there were opportunities to attend a track meet, a golf tournament for members and students, a tennis tournament, and a baseball game. During the latter part of the afternoon an inspection of the laboratories was made. About 150 attended the dinner which preceded the technical program.

These two groups have been holding annual joint meetings such as that described above for several years. This year, two such joint meetings for the presentation of student papers were held. They plan to hold two each year in the future, one in Portland in the winter, and the other in Corvallis in the spring.

PAST BRANCH MEETINGS

University of Akron

Talk by Glen O. Hite, Student, on Branch Affairs. Election of officers as follows: Harman Shively, Chairman; T. Wayne Brewster, Secretary; Neil Dickinson, Treasurer. May 16. Attendance 13.

Alabama Polytechnic Institute

General discussion. May 18. Attendance 30.

University of Arizona

Talk on development of Railroads, by Philip Hart, Student. *Types and Methods of Rectification*, by C. S. Wilcox, Student. April 25. Attendance 12.

Piezo Electricity, by W. Fraps, Student. May 9. Attendance 12.

Election of officers as follows: W. T. Brinton, Chairman; W. Fraps, Vice-Chairman; Carl Ludy, Secretary; Jack Rogers, Treasurer. May 16. Attendance 10.

Life of Pupin, by Frank J. Reitz, Student. May 24. Attendance 10.

University of Arkansas

Agricultural Engineering, by Professor D. G. Carter. Films—"The Panama Canal" and "Big Deeds." Joint meeting with the A. S. M. E. and A. S. C. E. May 14. Attendance 30.

Brooklyn Polytechnic Institute

Election of officers as follows: George Morton, President; Ivan Block, Vice-President; Frank Anderson, Secretary; Lorenzo Higgins, Treasurer. May 21. Attendance 38.

Testimonial dinner given to Professor Clyde C. Whipple. May 21. Attendance 78.

University of California

Inspection trip to Southern California Edison Co. Big Creek Power projects. May 8-11. Attendance 11.

Clarkson College

Railway Signaling, by H. W. Jones, Student;

Automatic Train Control on the Pennsylvania Railroad, by E. V. Dickinson. May 6. Attendance 15.

Election of officers as follows: S. Whitaker, Chairman; C. L. Brown, Secretary; C. O. McNairn, Treasurer. May 7. Attendance 50.

Annual Spring Banquet. Captain Broadfield, Troop B located at Malone Barracks, gave an account of the experiences of troopers. May 13. Attendance 40.

Clemson Agricultural College

Election of officers as follows: C. E. Jarrard, Chairman; G. A. Douglass, Secretary-Treasurer. Refreshments. May 15. Attendance 24.

Colorado Agricultural College

Strong Electrolytes, by Professor Johnson. April 28. Attendance 11.

Election of officers as follows: Henry Wamboldt, President; F. L. Poole, nominated for Counselor. May 13. Attendance 24.

University of Colorado

Annual fry. May 26. Attendance 35.

Election of officers as follows: Robert Partington, President; Frank Lightburn, Vice-President; John Buffo, Secretary; John Nelson, Treasurer. Refreshments. June 4. Attendance 25.

Cooper Union

The Photoelectric Cell, Its Characteristics and Commercial Application, by August Mundell, Student. April 2. Attendance 26.

A. Wolfrey, Weston Electrical Instrument Corp., presented a film on the operation and manufacture of all the primary types of meters. April 24. Attendance 40.

University of Detroit

Electricity and the Medical Profession, by F. W. Bramigk, of Plymouth, Mich. May 22. Attendance 55.

Banquet. Speakers as follows: Prof. Harry O. Warner, Counselor; T. N. Lacy, Michigan Bell Telephone Co.; Rev. J. P. Morrissey, Regent College of Engg.; N. S. Diamant, Chrysler Corp.; Professors Robert Blakeslee and Ralph Tapy. Eddie McGrath acted as toastmaster. June 3. Attendance 58.

Drexel Institute

The Effect of Lightning on Transmission Lines, by E. R. Saul, Student. Film—"Electrical Measuring Instruments." May 28. Attendance 30.

University of Florida

Election of officers as follows: Clyde Booth, President; J. L. Sanders, Vice-President; Ernest Menendez, Secretary-Treasurer. April 21. Attendance 25.

Talks by Professor J. E. Weil and several students. May 16. Attendance 25.

Georgia School of Technology

Election of officers as follows: B. L. Palmer, Chairman; J. Winn, Vice-Chairman; H. A. List, Secretary-Treasurer. N. H. Lassiter, Student, read a paper on the Fynn-Weichsel motor. April 8. Attendance 65.

University of Idaho

Discussion of plans for the Engineers' Show. May 6. Attendance 15.

Engineering Achievements of the Westinghouse Elec. & Mfg. Co. During 1929, by Wayne McCoy, Jack Donlon, and Donald Russel, Students. Illustrated. May 8. Attendance 17.

Iowa State College

Election of officers as follows: George A. Estel, President; John R. Lewis, Vice-President; Arthur W. Chewning, Secretary-Treasurer. May 12. Attendance 15.

State University of Iowa

Arc Welding and Resistance Welding, by F. Wilkins, Student. April 2. Attendance 32.

Film—"The Process of Making Steel, a Bethlehem Product." April 9. Attendance 12.

Neon Type Circuit Breaker, by J. Wendel, Student. Illustrated.

Deion Circuit Breakers, by G. I. Utterback, Student. April 30. Attendance 36.

Film—"Ford Car in the Process of Making." April 23. Attendance 12.

Rural Electrification, by M. Huntington, Iowa Railway and Light Co. May 7. Attendance 42.

Causes and Amount of Loss in Defective Telephone Circuits, by Mr. Bathe, Northwestern Bell Telephone Co. Illustrated. May 14. Attendance 44.

Kansas State College

Election of officers as follows: H. E. Trekell, President; L. E. Fritzinger, Vice-President; E. W. Bennett, Secretary; B. I. Cousins, Treasurer. May 8.

University of Kansas

Election of officers as follows: Harry Immich, Chairman; James Swafford, Secretary; Robert Meyer, Treasurer. May 15. Attendance 33.

Lafayette College

Arthur H. Edmondson elected Chairman. May 6. Attendance 17.

Lehigh University

Alternator Magnetization Curves, by W. P. Wills, Student;

The State Line Generating Station, by J. C. O'Connell, Student;

Some Sidelights on the Senior Inspection Trip, by Wm. Foley. Election of officers as follows: P. W. Seal, President; T. A. Wolfe, Vice-President; L. R. Wanner, Secretary; E. C. Easton, Treasurer. May 7. Attendance 35.

Lewis Institute

Recent Discoveries in the G. E. Laboratories, by J. F. Sanborn, General Elec. Co. Joint meeting with W. S. E. May 16. Attendance 62.

Distortion of Telephone Quality, by Burke Smith, Illinois Bell Telephone Co. Joint meeting with W. S. E. May 16. Attendance 66.

An Address to Engineers, by Charles Morse. Joint meeting with W. S. E. May 23. Attendance 58.

Marquette University

Business meeting. May 6. Attendance 9.

Michigan State College

Election of officers as follows: Robert Deering, Chairman; Clem Woodard, Vice-Chairman; Howard Morse, Secretary. June 3. Attendance 24.

School of Engineering of Milwaukee

Amateur Radio Station W9SO, by Wm. P. Gainer, Student;

Heaviside's Operational Calculus, by Professor I. C. Fischer. Illustrated. James Correll and D. Oakland, Students, presented a lecture on the Westinghouse Steam Turbine. Luncheon and inspection trip through W9SO followed. May 14. Attendance 60.

Mississippi A. & M. College

Election of officers as follows: J. M. Leigh, Chairman; A. H. Peale, Vice-Chairman. May 12. Attendance 25.

Missouri School of Mines

Three sound films as follows: "The Conquest of the Cascade," "The Electric Ship," and "Modern Trend in Turbine Design." May 20. Attendance 65.

University of Missouri

Election of officers as follows: R. L. Young, Chairman; L. F. Muench, Vice-Chairman; Walter Sevchuk, Secretary-Treasurer; C. M. Wallis, Corresponding Secretary. May 6. Attendance 19.

Montana State College

Repairing a Generator, by George Read, Student. Editorial from the *G. E. Review*, presented by Homer Morton, Student.

A Cathode Ray Oscillograph with Norinder Relay, presented by Vincent Morgan, Student. May 14. Attendance 145.

Simulating Sunlight, by M. Luckiesch, presented by Earle Rudberg, Student;

Automatic Telephone Exchange in Butte, by Lowell Kurtz, Student; Election of officers as follows: Bruce Mull, Chairman; Al Greiner, Vice-Chairman; Wm. McKay, Secretary; Harrell Renn, Treasurer. May 29. Attendance 146.

University of New Mexico

David Mitchell, delegate to the meeting of the 7th Geographical District, held at Columbia, in March, gave a report of the meeting and extracts of the various papers presented. April 1. Attendance 10.

College of the City of New York

Lightning and Lightning Protection, by W. S. Hill, General Electric Co. Moving pictures followed. May 15. Attendance 15.

Election of officers as follows: John Preuss, Chairman; Charles Hachemeister, Vice-Chairman; Howard Klein, Secretary; Nathan Levy, Treasurer. May 29. Attendance 25.

New York University

Skin Effects in Tubular Conductors, by Frank Pagliughi, Student;

Economic Aspect of Hydroelectric Power Plants, by John Iijima, Student;

Synchronizing at the Load, by Eric Salo, Student;

Gas Electric Drive for Light Automotive Vehicles, by Frank Castiglia, Student. May 6. Attendance 16.

North Carolina State College

Appointment of various committees for next term. May 20. Attendance 30.

University of North Carolina

The Cathode Ray Oscillograph, by Professor R. F. Stainback. Election of officers as follows: George D. Thompson, President; James Duls, Vice-President; Charles Hayes, Secretary; Robert Hubbard, Treasurer. May 22. Attendance 30.

University of North Dakota

Film—"Seeing Through The Opaque," and lecture by A. E. Eynon, Student;

The Westinghouse Advisory Board, by Robert Florance, Student. May 14. Attendance 22.

University of Notre Dame

Nomination of officers. Entertainment and social program prepared by the Progressive Committee. May 14. Attendance 95.

Election of officers as follows: Earl Brieger, Chairman; John Perone, Vice-Chairman; H. Perry, Secretary; J. O'Brien, Treasurer. May 24. Attendance 40.

Ohio Northern University

Thyrite, a New Material for Lightning Arresters, by M. Luikart, Student. May 1. Attendance 12.

Hyperbolic Functions, by Professor Whitted. May 15. Attendance 16.

Oklahoma A. & M. College

The following papers presented by Students:

Trend of Modern Circuit Breaker Design, by Walter Hoss;

History of Vacuum Tube Development, by J. R. Duncan;

Wave Propagation from an Electrodynamic Speaker, by Eldon Peek;

Calculation of Constants of Actual Line from Electrical Constants of a Simulating Network, by Roy Nelson. May 15. Attendance 15.

Annual joint meeting of the Oklahoma City Section and Student Branches of University of Oklahoma and Oklahoma A. & M. College. (For complete report see Student Activities Dept.) May 18. Attendance 60.

University of Oklahoma

Election of officers as follows: G. Scott Hammonds, Chairman; Elmer Prag, Vice-Chairman; Bill Fell, Secretary-Treasurer. Film—"Telephotograph." May 15. Attendance 22.

University of Pittsburgh

Discussion of Branch Activities. April 24. Attendance 80.

Film—"A Trip though Europe" presented by W. A. Billhartz, Student. May 1. Attendance 80.

Film—"Arc Welding." Joint meeting of all engineering departments. May 8.

Effect of Electric Shocks, by E. D. Zimmerman, Student;

Evolution of the Vacuum Tube, by G. L. Bolender, Student. May 15. Attendance 78.

Tenth Annual Banquet. *Preparation*, by Dean R. C. Clothier. Talks by several Students, Professor H. E. Dyche, and P. H. Powers, West Penn Power Co. May 21. Attendance 102.

Pratt Institute

Inspection trip to the General Electric Co. at Schenectady, followed by a banquet at which talks were given by F. L. Kemp, Supt. of Testing Dept., G. E. Co., A. L. Cook, Supervisor, Course in Elec. Engg., and S. S. Edmands, Director of the School of Science and Technology. May 15-16. Attendance 65.

Election of officers as follows: J. E. Cook, Chairman; B. M. Pactor, Vice-Chairman; J. A. Hoag, Secretary; W. M. Gardner, Treasurer. June 3. Attendance 85.

Purdue University

Engineering Projects Undertaken by The City of Athens, Greece, by C. E. Hines, Uland Construction Co. Election of officers as follows: A. Simon, Chairman; C. B. Shields, Vice-Chairman; C. B. Bruse, Secretary; E. T. Sherwood, Treasurer. May 15. Attendance 150.

Rhode Island State College

Election of officers as follows: G. Z. Verros, Chairman; J. A. Murgo, Vice-Chairman; Michael R. Lettieri, Secretary-Treasurer. May 3. Attendance 23.

University of South Carolina

Sound Picture Systems, by W. E. Crum, Student;

What Television Offers, by W. S. Smith, Student. May 16. Attendance 19.

General discussion of Branch affairs. May 23. Attendance 9.

Opportunities, Future Duties, Culture, and Development of the Engineer, by Professor W. S. Rodman, Vice-President District No. 4, A. I. E. E. May 30. Attendance 21.

University of Southern California

Election of officers as follows: Rodney Lewis, Chairman; Harry Cook, Vice-Chairman; J. G. Ellis, Secretary; Donald Hooker, Treasurer. May 14. Attendance 40.

Test of Airbreak Induction Motor Switches, by Mr. McCarter, Student. May 22. Attendance 36.

Stanford University

Election of officers as follows: Victor Siegfried, Chairman; W. R. Triplett, Vice-Chairman; G. E. J. Jamart, Secretary-Treasurer. May 22. Attendance 15.

Swarthmore College

A-C. Rectifiers, by Lewis Fussell, Jr., Student;

Synchronous Motors, by Henry Hadley, Student. May 12. Attendance 10.

The Fynn-Weichsel Motor for Power Factor Correction, by Leon A. Rushmore, Student;

Power Factor Correction via Synchronous Condensers, by Lewis Fussell, Jr., Student;

The Double Duty of Synchronous Motors, by L. E. Jewett, Student. May 19. Attendance 8.

Texas A. & M. College

W. W. Lynch, Texas Power & Light Co., gave a talk describing the construction of a transmission line in West Texas under very difficult conditions, accompanied by motion pictures showing the actual construction of this line. May 2. Attendance 61.

First Annual Engineers Day and Electrical Show. Each department exhibited the various phases of its work. May 10.

University of Vermont

Single-Phase Loading of Three-Phase Circuits, by F. E. Beckley, Student. May 19. Attendance 13.

Virginia Polytechnic Institute

C. V. West, elected Chairman. May 22. Attendance 20.

State College of Washington

Election of officers as follows: L. Engvall, President; L. N. Hatfield, Vice-President; E. W. Graf, Secretary; George O'Brien, Treasurer. May 14. Attendance 18.

A Vacuum Tube Voltmeter, by Lester Hatfield, Student;

Heat Control in Radio Transmitters, by Professor O. E. Osburn. May 28. Attendance 16.

University of Washington

Telephone Outside Plant Engineering, by F. C. Young, Pacific Telephone and Telegraph Co. April 4. Attendance 26.

Cup and pennant won by the electrical engineers for the best open house exhibition presented to Robert Kettenring. *Sectional Paper Machine Drive and Industrial Control*, by Mr. Howe, Westinghouse Elec. & Mfg. Co.

Washington University

Modern Developments in Communication and the By-Products of Telephony, by L. S. O'Roark, Employment Director, Bell Telephone Laboratories, Inc. May 12. Attendance 37.

Patent Situation, by R. M. Eilers. Mr. Rissman of the Eastman Kodak Co. gave a demonstration of Kodacolor Photography. May 15. Attendance 33.

Election of officers as follows: Joyce Pillsbury, Chairman; K. Steinhauer, Vice-Chairman; Paul Grivet, Secretary-Treasurer. May 26. Attendance 30.

West Virginia University

The following talks were given by Students:

Talkies and Television, by G. H. Hollis;

Duquesne Light and Power Station, by E. M. Hausford;

Carnegie Steel Plant, by O. R. Allen;

Homestead Steel Plant, by G. S. Garrett;

Springdale Power Station, by C. C. Coulter;

Power Plant Boilers, by E. Milam;

Westinghouse Elec. & Mfg. Co., by H. H. Kincaid;

Electric Steel Mill Drive, by G. C. Barnes;

Bell Telephone Exchange, by R. N. Kirchner. May 5. Attendance 45.

University of Wisconsin

Discussion on the cathode ray oscillograph by L. C. Larson, Instructor in Electrical Engineering. April 30. Attendance 25.

Yale University

Election of officers as follows: E. R. Eberle, President; R. S. Newhall, 2nd, Secretary; R. A. Hackley, Treasurer.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August, when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, MAY 1-31, 1930

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ADVANCED MATHEMATICS FOR STUDENTS OF PHYSICS AND ENGINEERING.

By D. Humphrey. N. Y., Oxford Univ. Press; Lond., Humphrey Milford, 1929. 2 v. in 1. 9 x 6 in., cloth. $4.25.

This textbook is based on the work done at the London Polytechnic in the fourth and fifth years' courses by students preparing for Advanced National Certificates in mechanical and electrical engineering. It aims to give students a knowledge of the principles of as many of the branches of mathematics required in their other subjects as is possible in a book of reasonable size.

APPLIED MECHANICS.

By Alfred P. Poorman. 3rd edition. N. Y., McGraw-Hill Book Co., 1930. 306 pp., diagrs., 9 x 6 in., cloth. $2.75.

A textbook for undergraduate students of engineering which makes large use of graphic methods and contains many illustrative examples. The new edition has been rearranged and contains additional examples.

ARTICULATED LOCOMOTIVES.

By Lionel Wiener. N. Y., Richard R. Smith, Inc., 1930. 628 pp., illus., diagrs., tables, 9 x 6 in., cloth. $10.00.

Although based on the author's "Locomotives Articulées," two-thirds of this book are new matter, the preface states.

The book discusses articulated and semi-articulated locomotives, locomotives with auxiliary or booster engines, and methods of utilizing the tender weight for propulsion. Data and drawings are given for many types, both current and obsolete, in unusual detail. A chronological list of progress in this field, a list of railroads using articulated locomotives and a directory of builders are included. The book is more complete than any other text in English.

AUFGABEN AUS TECHNISCHER MECHANIK. Statik Festigkeitslehre Dynamik.

By L. Föppl. Mün. u. Ber., R. Oldenbourg, 1930. 188 pp., illus., 10 x 7 in., cloth. 15.-r. m.

Contains 195 examples illustrating practical applications of mechanics in mechanical, electrical and structural engineering, and applied physics. Answers are given, and many complete solutions are included. The book is intended to give students practise in the use of technical mechanics.

CALCULUS.

By Egbert J. Miles and James S. Mikesh. N. Y., McGraw-Hill Book Co., 1930. 638 pp., 9 x 6 in., cloth. $3.75.

This introduction to calculus is marked by a number of alterations from the traditional method of presenting the subject. The concepts of functionality and functional behavior are given a positive content and made the basis of the further developments. By means of the idea of the rate of change, the student is led from this introduction into the chief processes of both differential and integral calculus.

DESIGN OF MASONRY STRUCTURES AND FOUNDATIONS.

By Clement C. Williams. 2d edition. N. Y., McGraw-Hill Book Co., 1930. 603 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

A classroom text which considers the subject from the aspects of stability, economy and architectural appearance. In this new edition, new material has been introduced upon phases that have undergone pronounced development, such as plain concrete, arch dams, and foundations. Other material has been revised, such as the chapter on retaining walls, where a simpler, more practical analysis replaces the classic treatment of Coulomb.

EISENVERBRAUCH UND WIRTSCHAFTLICHKEIT IM EISENBETONBAU.

By E. Röhr. Berlin, Wilhelm Ernst & Sohn, 1930. 95 pp., illus., tables, 10 x 7 in., paper. 8-r. m.

Describes a simple, rapid method for determining the amount of steel required in reinforced concrete structures. The book is intended to aid estimators and contains tables for rapid calculation.

EISERNE GITTERMASTE FUR STARKSTROM-FREILEITUNGEN; BERECHNUNG UND BEISPIELE.

By Wilhelm Taenzer. Berlin, Julius Springer, 1930. 65 pp., illus., diagrs., tables, 12 x 8 in., paper. 13,50 r. m.

A theoretical and practical discussion of the design of stee lattice poles and towers for overhead lines. Complete calculations are given for several examples.

THE ELDER PLINY'S CHAPTERS ON CHEMICAL SUBJECTS, Pt. 1. Edited with translation and notes by Kenneth C. Bailey. N. Y., Longmans, Green & Co.; Lond., Edward Arnold & Co., 1929. 249 pp., 10 x 7 in., cloth. $5.00.

The last English translation of Pliny's Natural History was published in 1855 and has long been out of print. The present translation, in the light of modern chemical knowledge, will be welcomed by all students of the history of science, as well as by students of the classics.

The selections included cover those sections of the earlier books which are concerned with chemical subjects, and the whole of Book 33, printed opposite the Latin text, and accompanied by copious notes and explanations. A second volume is to follow.

GENERAL CHEMISTRY.

By Harry N. Holmes. Revised edition. N. Y., Macmillan Co., 1930. 654 pp., illus., 9 x 6 in., fabrikoid. $3.50.

A text book for college freshmen who have had instruction in chemistry in the preparatory school. The book offers a year of general chemistry which aims to induce scientific thinking, rather than the accumulation of facts, and is marked by an abundance of homely illustrations and an interesting style.

HIGH-VOLTAGE CABLES.

By L. Emanueli. N. Y., John Wiley & Sons, 1930. 107 pp., illus., diagrs., 9 x 6 in., cloth. $2.50.

Five lectures by the eminent European specialist who developed the oil-filled cable. After an introductory outline of cable construction and cable types, the author discusses impregnating compounds, the electrostatic field, the dielectric from the viewpoint of cable impregnation, and the mechanical and electrical properties of finished cables. Emphasis is upon engineering principles rather than details of practise, making the book valuable to cable engineers generally.

Heat Power.

By Earle B. Norris and Eric Therkelsen. N. Y., McGraw-Hill Book Co., 1930. 376 pp., illus., 9 x 6 in., cloth. $3.50.

An introductory text for students of engineering, which aims to emphasize fundamental principles rather than current practise or mechanical details. The book departs from the usual arrangement by beginning with the internal-combustion engine, as more familiar to the modern youth than the steam engine.

History of Science and Its Relations with Philosophy and Religion.

By William Cecil Dampier-Whetham. N. Y., Macmillan Co., 1929. 514 pp., 9 x 6 in., cloth. $6.00.

This is the best attempt to tell the general story of science that has appeared since Whewell wrote his books on the history and philosophy of the inductive sciences, nearly one hundred years ago. In ten very readable chapters we have, not a detailed study of any one period or subject, but a complete outline of the development of scientific thought from the ancient world down to the present time. The inner meaning of science and its bearing on philosophy and religion are admirably emphasized.

Idraulica, v. 1.

By Giulio de Marchi. Milan, Ulrico Hoepli, 1930. 560 pp., illus., diagrs., 10 x 7 in., paper. 80 lire.

The first of two volumes covering the course in hydraulics given at the Royal School of Engineering, Milan. This volume discusses fundamental principles, hydrostatics, the flow of water in open and closed channels and underground, and the dynamic action of currents. Numerous bibliographies are included.

Materials of Engineering Construction.

By Francis W. Roys. N. Y., Ronald Press Co., 1930. 331 pp., illus., tables, 9 x 6 in., cloth. $4.00.

A practical textbook covering the characteristics and properties of the most used materials in a comprehensive manner, yet not too lengthy to be used as a text for students of engineering. The explanations and descriptions are brief and direct, current developments are considered, and illustrations are numerous and useful.

Mitteilungen des Institutes für Strömungsmachinen der Technischen Hochschule Karlsruhe, Heft 1. Edited by W. Spannhake. Mün. u. Ber., R. Oldenbourg, 1930. 85 pp., illus., diagrs., 11 x 8 in., paper. 8.-r. m.

The first number of a new serial devoted to the work of the Institute, which is primarily interested in the investigation of turbo-machinery.

This issue contains a brief description of the equipment for investigating turbines and pumps, and reports on one purely theoretical and two experimental investigations. Two of the latter deal with the theoretical potential flow through a turbine wheel and its comparison with the actual flow. The remaining paper describes the construction and use of a new apparatus for measuring the forces on the blades of a turbine.

Modern Lighting.

By Frank C. Caldwell. N. Y., Macmillan Company, 1930. 386 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.25.

A textbook on illumination as practised to-day. The requirements for good lighting; light sources; light modification; lighting systems and their design; proper lighting for shops, schools, homes, streets, etc., light projection; radiation and color, are discussed in a concise way, with enough detail for ordinary needs, but without overloading the book.

Oil Fields in the United States.

By Walter A. Ver Wiebe. N. Y., McGraw-Hill Book Co., 1930. 629 pp., illus., maps, tables, 9 x 6 in., cloth. $6.00.

Intended to provide a compact description in a scientific way of all these oil fields, which will obviate the necessity of examining the scattered periodical literature. Adopting a new "tectonic" classification, the oil fields are grouped into "provinces," which are subdivided into "districts." The stratigraphy of each province and district are given in detail, with emphasis upon the conditions that have controlled the accumulation of oil and gas in them. Selected bibliographies are appended to each chapter.

Piping Handbook.

By J. H. Walker and Sabin Crocker and others. N. Y., McGraw-Hill Book Co., 1930. 763 pp., illus., tables, 7 x 5 in., fabrikoid. $5.00.

This book brings together in convenient form a large amount of information on the properties of fluids, the metallurgy of pipe materials, apparatus, and piping for many purposes, frequently wanted by engineers interested in piping work in power plants, distributing systems, and factories.

The Principles of Coal Property Valuation.

By A. W. Hesse. N. Y., John Wiley & Sons, 1930. 183 pp., illus., graphs, tables, 7 x 5 in., fabrikoid. $3.00.

A guide to executives and engineers upon the examination and valuation of virgin coal lands and operating properties. The factors that are to be considered are presented, together with formulas and tables needed in the work. The book is revised and enlarged from a series of articles published in "Coal Mine Management."

Some Writers on Lime and Cement from Cato to Present Time.

By Charles Spackman. Cambridge (Eng.), W. Heffer & Sons, 1929. 287 pp., 9 x 6 in., cloth. 15s.

A chronological list, with notes indicating the nature of their writings and, in some instances, quotations from them. The author has for many years been a student of the chemistry and technology of structural cements, and his book is an interesting contribution to the history of the subject.

Structure of Line Spectra.

By Linus Pauling and Samuel Goudsmit. N. Y., McGraw-Hill Book Co., 1930. (International series in Physics). 263 pp., diagrs., tables, 9 x 6 in., cloth. $3.50.

Designed primarily for workers in spectroscopy, this book contains a theoretical discussion of the structure of line spectra, based on the visualizable vector model of the atom. The book will also be helpful to students of theoretical physics who wish knowledge of spectroscopic facts and laws.

Technique of Executive Control.

By Erwin Haskell Schell. 3rd edition. N. Y., McGraw-Hill Book Co., 1930. 171 pp., 7 x 5 in., cloth. $2.00.

This book discusses the problems of the executive. The tools of executive control, the duties of the executive, the control and stimulation of subordinates, and difficulties with subordinates, superiors and equals, are discussed. The author does not offer conclusions or set standards, but rather tries to suggest avenues of reflection that will lead to the requirement of a successful personal method.

Technische Tabellen und Formeln.

By W. Müller. Ber. u. Lpz., Walter de Gruyter & Co., 1930. 151 pp., 6 x 4 in., cloth. 1,80 r. m.

A convenient collection of formulas and tables for electrical and mechanical engineers. Includes the data most frequently wanted relating to heat, the strength of materials, machine elements and electricity. The volume is of convenient size for the pocket.

Television, To-Day and To-Morrow.

By Sydney A. Moseley and H. J. Barton Chapple. N. Y., Isaac Pitman & Sons, 1930. 130 pp., illus., port., 9 x 6 in., cloth. $2.50.

A popular account of Baird's work on television which gives a detailed description of the apparatus and the way in which it works. The most complete account of the Baird system that has appeared.

Toward Civilization.

Edited by Charles A. Beard. N. Y., Longmans, Green & Co., 1930. 307 pp., 9 x 6 in., cloth. $3.00.

The question whether modern life is a jangle and a confusion or the prelude to a better future is here discussed by a number of prominent engineers. Robert A. Millikan, Elmer A. Sperry, Roy V. Wright, Dexter S. Kimball, L. W. Wallace, William E. Wickenden, Michael Pupin and others contribute to the discussion which defends the changes caused by science and machinery against the criticisms brought in the name of humanism, religion and esthetics.

Die Wirtschaftlichkeit der Energiespeicherung für Elektrizitätswerke.

By Ludwig Musil. Berlin, Julius Springer, 1930. 143 pp., diagrs., tables, 10 x 7 in., paper. 18.-r. m.

A discussion of the economies that may be expected from accumulators of energy by hydroelectric, steam-electric and combined power plants. Proceeding from general principles, the author develops suitable equations and applies them to specific cases.

Zur Frage der Bewertung von Holz-und Eisenschwellen.

By Dr.-Ing. Diehl. Berlin, V. D. I. Verlag. 1930. 58 pp., illus., tables, 8 x 6 in., paper. 3,50 r. m.

A comprehensive discussion of the relative merits of steel and wood ties, based upon the experience of the German railways. The author's conclusions are generally favorable to the steel tie.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 West 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, who has had broad experience in the design and development of fractional hp. a-c. and d-c. motors. Also experience in application engineering. Apply by letter giving full particulars. Location, Middle West. W-67-C.

DIESEL PLANT BETTERMENT AND SERVICE ENGINEER, with some steam experience for plant betterment and service division of large utility management organization for work in Latin America. Five to ten years' operating experience, preferably in public utility stations, necessary. Essential that applicant be fully informed as to operation, maintenance and design of up-to-date steam and Diesel-electric stations; should be capable of analyzing operating results and costs as well as rendering all kinds of service in connection with operation of steam or Diesel plants. Technical training or its equivalent required, as men must supply technical knowledge for present operating force. Apply by letter giving full record of education and past experience, stating age, salary expected, and when available. Also languages spoken and any countries in Latin America to which applicant will not consider assignment. Headquarters, New York City. W-1220.

RECENT GRADUATES in Electrical Engineering or Physics who have had some experience in meter work and instruments, and wish to specialize therein. Scope of the laboratory work embraces practically the entire field of electrical measurements. Exceptional opportunity for advancement. Apply by letter giving complete details of education, training and experience. Location, East. X-5543.

EXPERIENCED ENGINEER, competent to act as assistant to the chief engineer of organization to handle the design of condensers suitable for a-c. operation for the various industrial uses. Apply by letter. Location, New York City. W-1217.

ELECTRICAL ENGINEER, competent to handle electrical and mechanical installation and maintenance work of a large coal company. One having had mining experience preferred. Must be at least 30 years of age, a good organizer and executive, capable of commanding a salary of $4000 to $5000 per year. In reply state all qualifications and list previous positions. Location, East. W-1317.

MEN AVAILABLE

ELECTRICAL-MECHANICAL ENGINEER, Ohio State Univ., 31, married; G. E. Test, 2 years with public utility on electrical substation engineering including design, operation, maintainance, 3 years as development engineer on machine equipment with large manufacturer of electrical apparatus, one year as superintendent of factory making small metal stampings. Now available. C-1068.

ENGINEER, Harvard graduate, married, age 28. Seven years' experience in designing, selling, and supervising production of electrical measuring and signaling devices. Desires connection with electrical manufacturing company offering opportunity for advancement. Location preferred, in or around Newark or New York City. Available on two weeks' notice after June 15th. C-5343.

ELECTRICAL ENGINEER, 25, single. E. E. degree, Columbia University. Two years' experience with Eastern utility, including cadet course and distribution design and estimating. Desires connection with technical department of progressive utility. Available on two weeks' notice. C-7480.

GRADUATE, 1930, of a well-known university, with B. Sc. in Electrical Engineering, desires a position with a company doing engineering work, preferably electrical, age 22; single. Not afraid of hard work. Location immaterial. C-5938.

GRADUATE ELECTRICAL ENGINEER, 35, experienced transformer engineer. Twelve years with General Electric Co., Schenectady, Pittsfield Test Course, Sales, Engineering Depts. Transformer quotation, design, development, factory engineering supervision, technical reports, investigating materials, power factor, distribution systems. Technical school instructor. Desires position design, sales, consulting engineer or instructor. Location preferred, East or South. C-7321.

ELECTRICAL ENGINEER with profound knowledge of the fundamental theories of electricity, magnetism and general physics; thoroughly experienced design, development of electromagnetic, electromechanical applications, (Motors, generators, industrial controls, etc.). Now director, research laboratory. Would consider new connections as director of research or chief engineer of motor or industrial control manufacturer. B-4975.

GENERAL MANAGER of large telephone system, experience abroad and in United States. Thoroughly up-to-date in designing, construction, maintenance, operation of telephone plants. Broad experience in securing franchises for public utility companies, South America. Wishes to associate with large or small telephone company. Could furnish additional capital for telephone system requiring same. C-7504.

RECENT GRADUATE, ELECTRICAL ENGINEER, 37, single, practical experience in motor repair and wiring; speaks German and Spanish. Desires position East or Middle West. C-7246.

GRADUATE ELECTRICAL ENGINEER, 27, single, well-trained in application of theory of practise. Two years' public utility experience in substation design, distribution engineering and estimating. Spent two years in China. Speaks Russian. Desires connection with American public utility operating abroad. Now employed in United States. C-7549.

ELECTRICAL ENGINEER, B. S. degree, age 33, Westinghouse sales course, 15 months sales assistant, three years technical advertising, four and one-half years development, sales, surveys on oil-electric locomotives. Executive ability. Desires sales position electric traction or industrial electrical equipment; or engineering with railroad electric traction department. References. State location. C-7545.

ELECTRICAL ENGINEERING GRADUATE. 1930. Wishes permanent employment in any work with a future in the electrical field. Considerable general business experience (bookkeeping, typing, etc.). Speaks German. Age 23. Married. Good references. C-7511.

MEASUREMENT AND CONTROL SPECIALIST seeks connection with commercial laboratory, public utility or manufacturer, in capacity of developing engineer or consultant. Broad and extensive experience with all types of electrical instruments, precision measurement, standardization and automatic control. Also experienced in pyrometry and automatic control. Correspondence invited. B-7245.

ELECTRICAL ENGINEER, single, age 24, 1929 graduate. At present employed by Mid-western utility. Desires position in South America. C-7583.

ELECTRICAL GRADUATE, 36, just returned from South America; long experience, construction of Central Stations, substations, allied lines, maintenance, tests, inspections, distribution, pole lines. One year, operating. Desires position foreign, domestic, or representative to manufacturers in Brazil or elsewhere. Languages, English, French, Portuguese, working knowledge Spanish, Italian, German. Best references. Available immediately. C-2021.

GRADUATE ENGINEER, with strong theoretical background. Extensive practical experience in public relations, valuation, rate-making, special economic studies, investigations and research. Well qualified as a junior executive for

large industrial or public utility corporation, or director of research, special investigations or publicity. Now engaged as executive. Available on reasonable notice. C-6733.

ELECTRICAL ENGINEER, 22, single. Recent graduate from the College of Electrical Engineering, University of Dayton, Dayton, Ohio; seeking position in any electrical line with opportunity for advancement. Available June 9th. C-7456.

ENGINEER, having 10 years' practical experience in transmission, distribution and road construction, is desirous of a connection with a progressive concern. Perfect knowledge of French and Russian. Location, Europe. B-7412.

GRADUATE ELECTRICAL ENGINEER, comprehensive experience, 25 years, Westinghouse, Crocker-Wheeler, etc., Electrical and mechanical design of most types of a-c. and d-c. machinery. Has new ideas ready for development. Would like to connect with enterprising manufacturer to undertake special development work of definite character. Patent pending, shop and executive experience. C-30.

ELECTRICAL ENGINEERING PROFESSOR, unique teaching experience desires change. Best of references. Commercial testing and research experience as a professional background in addition to advanced studies. Employed at present midwest State University. C-2892-1336.

ELECTRICAL ENGINEER, university graduate, age 29, single, 5 years' public utility experience in design of power stations and substations, including G. E. Test Course. Two years active sales of motors, generators, and control, all types. La Salle Extension University Business Administration course. Desires position with growing organization anywhere. C-7612.

ELECTRICAL ENGINEER, 45, married. Stanford graduate, Westinghouse training sucessful in handling men, nine years in responsible positions with large California public utility in hydroelectric development, power plant and substation design, construction and tests, Excellent references. Seeks new position. Available immediately. Pacific Coast preferred. C-7644-306-C-3.

GRADUATE ELECTRICAL ENGINEER, 35. Five years' diversified experience with eastern public utility companies; testing, series street lighting, estimator, reports, budgets, O. H. to U. G. conversion, practical and theoretical calculations in distribution problems. Good knowledge of mathematics. Speaks English, Italian, French. Desires position as assistant to distribution engineer. Location, immaterial. C-7596.

ENGINEER-EXECUTIVE, 34, married, Cornell University graduate, business-minded with record of executive achievement, thirteen years' experience east and southwest including supervision of design, construction, operation of transmission, distribution, power stations, system operation. Employed present position past seven years as superintendent operating division large utility. Available reasonable notice. C-7639.

SUPERINTENDENT, graduate electrical engineer desires connection with public utility as district superintendent, distribution engineer, or construction superintendent. Two years' experience central station operation and distribution system maintenance; General Electric Test; five years' substation design and inspection with large utility. Employed. Age 30. Married. Location anywhere in U. S. A. C-7513.

MECHANICAL AND ELECTRICAL CONSTRUCTION SUPERINTENDENT, age 45, married, American. Speaks some Spanish. Fifteen years' experience in construction work; dams, tunnels, power plants, power lines, substations, and general construction equipment and plant installation. C-7626-305-C-17.

ELECTRICAL ENGINEERING TEACHER, B. S. and M. S. in E. E., G. E. Test, eleven years' teaching experience with recognized technical school. Desires permanent position. Available September. Excellent references. Age, 36. C-5807.

GRADUATE ELECTRICAL ENGINEER, age 31, married. Eight years' experience including two years G. E. Test, one year sales, one year valuation of lighting and telephone equipment and five years on electrical construction including estimating, layout work, and supervising installations. Desires a permanent connection with a future. B-9090.

GRADUATE ELECTRICAL ENGINEER, experience consists of three years engineering with a New York Central Railway and two years design and layout of electrical equipment for schools. Desires position with company doing transmission, railroad or equipment work. Especially useful where civil engineering knowledge is necessary. C-7535.

EXPERIENCED METER ENGINEER, 36, technical graduate. Familiar with all types of metering, also power plant equipment, distribution systems and Public Utilities operation. Executive ability. Desires change to growing property. Location preferred Eastern States. C-7295.

ENGINEER, technially educated, above average height, mature in judgment and of wide experience on engineering work, in U. S. and in foreign countries. Engineering experience covers design, specifications, estimates, selecting and purchasing of equipment and materials, supervising its construction and installation on power, industrial and municipal improvement. C-408.

SUPERINTENDNET, general foreman or field engineer for construction company or utility (electric, gas, or water), on construction maintenance, or operating. Young, energetic, ability and experience in handling large crew and jobs of many details. Good organizer. B-9380.

YOUNG SALES ENGINEER, electrical training at Worcester Polytechnic Institute. One year manufacturing, three years' sales experience. Would like opportunity to develop sales or assist in sales management. C-5431.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of June 4, 1930, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BUCHANAN, OMAR B., Patent Attorney, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
CARTER, HERBERT G., Consulting Engr., Donoghue & Carter, Sydney, Australia.
SAATHOFF, GEORGE W., Chief Construction Engr., Henry L. Doherty & Co., New York, N. Y.

To Grade of Member

ASHBROOK, ROY B., Communication Engr., Southern Calif. Edison Co., Los Angeles, Calif.
AXTELL, CLINTON J., Asst. Engr., General Elec. Co., Erie, Pa.
BANCKER, ELBERT H., Central Station Engg., Dept., General Elec. Co., Schenectady, N. Y.
BIBBER, HAROLD W., Application Engr., General Elec. Co., Schenectady, N. Y.
BURBANK, EDWARD W., Dallas District Mgr., Allis-Chalmers Mfg. Co., Dallas, Texas.
BUSCH, A. J., Telephone Circuit Design Engr., Bell Telephone Laboratories, Inc., New York, N. Y.
CLEM, J. E., Elec. Engr., General Elec. Co., Schenectady, N. Y.
COLES, EDMUND P., Manager, General Elec. Co., Charlotte, N. C.
CREE, GEORGE G., Section Head, General Elec. Co., Schenectady, N. Y.
ESHBACH, OVID W., Special Asst., Personnel Dept., American Tel. & Tel. Co., New York, N. Y.
FREDERICK, Wm. H., Elec. Engr., W. S. Barstow & Co., Reading, Pa.
HILL, WILLIAM S., General Elec. Co., New York, N. Y.
JACOBI, Wm. O., Elec. Engr., Omaha & Council Bluffs St. Ry. Co., Omaha, Nebr.
KEYES, CLIFT B., District Mgr., General Elec. Co., New York, N. Y.
KING, EDWARD D., Vice-President and General Mgr., Tonawanda Power Co., No. Tonawanda, N. Y.
KUHN, CLARENCE W., Development Engr., Cutler-Hammer, Inc., Milwaukee, Wis.
LEAR, JOHN E., Prof. of Elec. Engg., University of North Carolina, Chapel Hill, N. C.
LEE, BENJAMIN F., Manager, Elec. Dept., Niagara Falls Pr. Co., Niagara Falls, N. Y.
LOCKE, FRANK J., Supervising Methods Engr., Western Elec. Co., New York, N. Y.
McLAREN, Wm. F., Chief Draftsman, Canadian Westinghouse Co., Hamilton, Ont., Canada.
NAETER, ALBERT, Professor and Head of Elec. Engg. Dept., Oklahoma A. & M. College, Stillwater, Okla.
PRICE, KARL D., Relay, Meter and Automatic Substation Engr., Columbus Railway Pr. & Lt. Co., Columbus, Ohio.
ROBERTS, LEROY C., Meter Supervisor, Staten Island Edison Corp., Staten Island, N. Y.
SANFORD, WARREN B., Plant Mgr., Bell Telephone Laboratory, Inc., New York, N. Y.
SCHARF, HENRY W., Consulting Engineer, Hastings-on-Hudson, N. Y.
SCOVILLE, GEORGE A., Vice-President and Sales Mgr., Stromberg-Carlson Tel. Mfg. Co., Rochester, N. Y.
SMITH, HARRY S., Section Engr., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
STODDARD, STANLEY W., Asst. Elec. Engr., New England Power Construction Co., Boston, Mass.
STONE, LELAND F., Field Engr., General Elec. Co., New York, N. Y.
VAN DEUSEN, HARRY N., Materials Engr., Bell Telephone Laboratory, Inc., New York, N. Y.
VAN LEAR, G. M., Elec. Engr., Rome Wire Co., Rome, N. Y.
WEGEL, RAYMOND L., Research Engr., Bell Telephone Laboratories, Inc., New York, N. Y.
WHITE, WILLIAM C., Designing Engr., General Elec. Co., Schenectady, N. Y.
WHITMAN, ALLEN L., Engr., American Tel. & Tel. Co., New York, N. Y.
WINANS, JAMES D., Engg. Asst., United Engineers & Constructors, Inc., Newark, N. J.

RECOMMENDED FOR TRANSFER

At meeting of June 20, 1930:

To Grade of Fellow

ADAMS, PATRICK H., Electrical Engineer, United Engineers & Constructors, Inc., Newark, N. J.

ANDEREGG, G. A., Cable Development Engr., Bell Telephone Laboratories, Inc., New York.
DENNIS, ROBERT E., Chief Electrical Engr., Westchester Lighting Co., Mt. Vernon, N. Y.
FLOOD, HENRY, Jr., Consulting Engr., Murray & Flood, New York.
NOE, JAMES B., Asst. Engr., Elec. Engg. Dept., N. Y. Edison Co., New York.
OSWALD, ARTHUR A., Radio Development Engr., Bell Telephone Laboratories, Inc., New York.

To Grade of Member

ALBERT, WILLIAM A., Asst. Design Engr., West Penn Power Co., Pittsburgh, Pa.
ALEXANDER, R. WARREN, In Charge of System Planning Section, Allied Engineers, Inc., Jackson, Mich.
ALEXANDER, THOMAS W- Jr., Asst. Engr. of Transmission, Bell Telephone Co. of Pa., Pittsburgh, Pa.
ALRICH, JOHN D., Locomotive Division, General Electric Co., Erie, Pa.
BOLLES, C. F., Engg. Asst., United Engineers & Constructors, Inc., Newark, N. J.
BOSSART, PAUL N., Research Engr., Union Switch & Signal Co., Swissvale, Pa.
BRADLEY, FRANCIS H., Building and Equipment Engr., Southern New England Telephone Co., New Haven, Conn.
BROOKS, J. A., Asst. Elec. Engr., N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
BUCHERT, EMIL, Asst. Engr., United Engineers & Constructors, Inc., Newark, N. J.
BURNS, HARRY R., Asst. Elec. Engr., Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.
COLLANDER, D. W., Elec. Engr., Canadian Westinghouse Co., Hamilton; Ont. Canada.
CASPER, ROY M., Engg. Asst., United Engineers & Constructors, Inc., Newark, N. J.
CHAPMAN, FRED I., Sales Engr., Westinghouse Elec. & Mfg. Co., Boston, Mass.
CHAPMAN, ROBERT L., Elec. Engr., General Elec. Co., Erie, Pa.
CLEMENTS, C. H., Cable Maintenance Supervisor, Southern New England Telephone Co., New Haven, Conn.
DAMBLY, HAROLD A., Asst. Engr., Philadelphia Elec. Co., Philadelphia, Pa.
DOOLITTLE, WALTER P., Industrial Engr., Kansas City Pr. & Lt. Co., Kansas City, Mo.
EISENMENGER, H. E., Asst. to Rate Engr., New York Edison Co., New York.
ELLIOTT, PARK, Field Engr., General Elec. Co., New York.
ENGQUIST, V. E., Elec. Engr., Northern States Pr. Co., St. Paul, Minn.
FLEMING, T. J., Transmission Engr., Associated Telephone Co. Ltd., Los Angeles, Calif.
GANNETT, D. K., Telephone Engr., American Tel. & Tel. Co., New York.
GARRETT, PERCY B., Engg. Supervisor, Westinghouse Elec. & Mfg. Co., San Francisco, Calif.
HARDY, RODNEY C., Elec. Engr., General Elec. Co., Cleveland, Ohio.
HART, CARLOS D., Supt. of Cable Shop, Western Elec. Co. Inc., Baltimore, Md.
HEBBERT, C. E., Asst. Engr., United Engineers & Constructors, Inc., Newark, N. J.
HIERONYMUS, T. G., Underground System Engr., Kansas City Pr. & Lt. Co., Kansas City, Mo.
JENKINS, F. O., Engineer, Kansas City Pr. & Lt. Co., Kansas City, Mo.
JONES, CHARLES R., Section Mgr., Westinghouse Elec. & Mfg. Co., New York.
KILLINGSWORTH, H. T., Division Plant Engr., American Tel. & Tel. Co., Cleveland, Ohio.
KNOX, CARLOS C., Engr., Byllesby Engg. & Mgt. Corp., Pittsburgh, Pa.
LANGFORD, J. A., Elec. Engr., Canadian & General Finance Co., Toronto, Ont., Canada.
MASTICK, R. W., Chief Engr., Pacific Tel. & Tel. Co., Seattle, Wash.
McCREA, HUGH A., Central Station Engr., General Elec. Co., Boston, Mass.
PALMER, JOE S., Substation Engr., Kansas City Pr. & Lt. Co., Kansas City, Mo.
PILGRIM, C. O., District Mgr., Locke Insulator Corp., Dallas, Texas.
RALL, ALBERT A., Standardization Engr. and Safety Supervisor, Kansas City Pr. & Lt. Co., Kansas City, Mo.
RODGERS, JAMES A., Chief Engr., Emerson Elec. Mfg. Co., St. Louis, Mo.
RYAN, PHILIP, Purchasing Agent, Cutler-Hammer, Inc., Milwaukee, Wis.
SAMSON, HARRY W., Head of Data Bureau, General Elec. Co., Schenectady, N. Y.
SAYLES, EDGAR V., Investigations Engr., Allied Engineers, Inc., Jackson, Mich.
SCHELLENG, JOHN C., Radio Research Engr., Bell Telephone Labs., New York.
SCHRODER, J. H., Engg. Asst., United Engineers & Constructors, Inc., Newark, N. J.
SCOTT, K. L., Head of Permanent Magnet Development Dept., Western Elec. Co., Chicago, Ill.
STEVENS, JOHN C., Consulting Engr., Stevens & Koon, Portland, Oregon.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1930.

Adams, L. J., First National Productions Corp., Burbank, Calif.
Asbury, D. N., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Baden, M. W., (Member), Baden Bldg., Winfield, Kans.
Bolingbroke, J., (Member), Standard Underground Cable Co., Hamilton, Ont., Can.
Bronson, J. T., General Electric Co., Cincinnati, Ohio
Brown, O. A., Iowa State College, Ames, Iowa
Butt, C. N., Puget Sound Power & Light Co., Seattle, Wash.
Chen, C. M., Philips China Co., Shanghai, China
Coffin, E. A., New England Power Co., Millbury, Mass.
Coleman, J. B., Mass. Institute of Technology, Cambridge, Mass.
Colville, F. P., (Member), Westinghouse Elec. & Mfg. Co., Cincinnati, Ohio
Cramer, L. E., A. G. Electrical Mfg. Company, Los Angeles, Calif.
Datshkovsky, J., Mexico Music Co., Mexico, D. F., Mex.
De Blieux, E. V., General Electric Co., Pittsfield, Mass.
Doyle, E. J., (Member), Commonwealth Edison Co., Chicago, Ill.
Dunfield, G. E., Hydro-Electric Power Commission of Ontario, Toronto, Ont., Can.
Engler, R. J., (Member), Electrical Research Products, Inc., Los Angeles, Calif.
Erickson, E. G., Coal Products Mfg. Co., Joliet, Ill.
Evans, S., Goat Radio Tube Parts, Inc., Brooklyn, N. Y.
Glaser, M., 2300 E. 13th St., Brooklyn, N. Y.
Gordon, H. J., Burke Electric Co., New York, N. Y.
Gummo, R. L., Westinghouse Elec. & Mfg. Co., Wilkinsburg, Pa.
Hamilton, G. L., Duquesne Light Co., Pittsburgh, Pa.
Hawley, D. C., Kansas City Power & Light Co., Kansas City, Mo.
Hess, O., 3973 Bliss St., Sunnyside, L. I.
Iwashita, G. K., University of Dayton, Dayton, Ohio
Jewell, R. G., General Electric Co., Schenectady, N. Y.
Johnson, J. W., Hugh L. Cooper & Co., Inc., New York, N. Y.
Kingdon, R. H., Square D Co., Detroit, Mich.
Krotzer, F. W., (Member), Iowa University, Iowa City, Ia.
Lennborg, E. O., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
McCorkle, D. S., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
McKee, E. R., Iowa State College, Ames, Iowa
McKibben, L. S., Electrical Research Products, Inc., Hollywood, Calif.
Monroe, R. A., Aluminum Co. of America, Pittsburgh, Pa.
Morrison, G. W., General Electric Co., West Philadelphia, Pa.
Nightingale, M., Bell Telephone Co. of Canada, Montreal, Que., Canada
Norton, L. R., Southwestern Bell Tel. Co., San Antonio, Tex.
O'Leary, B. J., Ohio Bell Tel. Co., Dayton, Ohio
Pallange, E. P., Marquette University, Milwaukee, Wis.
Palmer, H. G., Bell Telephone Co. of Canada, Montreal, Que., Canada
Parks, G. U., (Member), Montaup Electric Co., Fall River, Mass.
Patrick, S. V., General Electric Co., San Antonio, Tex.
Payne, L. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Shapiro, S., 117 West Court St., Warsaw, N. Y.
Sherwin, J. L., (Member), H. K. Ferguson Co., Cleveland, Ohio
Silverman, I. D., (Member), Samuel W. Hurowitz, Inc., New York, N. Y.
Simmons, H. A., Erie Lighting Co., Erie, Pa.
Steiert, G. A., General Electric Co., Schenectady, N. Y.
Templin, E. W., Electrical Research Products, Inc., Los Angeles, Calif.
Thompson, H. C., II (Member), St. Joseph Lead Co., Bonne Terre, Mo.
Van Allen, R. C., Chesapeake & Potomac Tel. Co., Washington, D. C.
Willis, B. S., Iowa State College, Ames, Iowa
Winters, J. C., Tilden Lumber Co., Oakland, Calif.
Total 54

Foreign

Castellan, G. E., General Electric Co., Ltd., Witton, Birmingham, Eng.
Lund, E. W., Kryolith Mine & Handels, Copenhagen, Denmark
Nogueira, F. P., Rio Grandense Light & Power Syndicate Ltd., Rio Grande do Sul, Brazil, So. Amer.
Pinedo, M., Compania Telefonica del Pacifico, Cali, Colombia, So. Amer.
Posada, E. E., Cia. Colombiada de Electricidad, Barranquilla, Colombia, So. America
Soi, H. R., (Member), Electrification Scheme, Sialkot, Punjab, India
Wright, E. P., Commonwealth Telegraph & Telephone Service, Melbourne, Australia
Total 7

OFFICERS A. I. E. E. 1929-1930

LOCAL HONORARY SECRETARIES

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.
H. W. Flashman, Aus. Westinghouse Elec. Co. Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.
F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 45 Bd. Beausejour, Paris 16 E., France.
F. W. Willis, Tata Power Company, Bombay House, Bombay, India.
Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.
Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.
W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

A. I. E. E. COMMITTEES

(A list of the personnel of Institute committees may be found in the June issue of the JOURNAL.)

GENERAL STANDING COMMITTEES AND CHAIRMEN

EXECUTIVE, Harold B. Smith
FINANCE, E. B. Meyer
MEETINGS AND PAPERS, A. E. Knowlton
PUBLICATION, W. S. Gorsuch
COORDINATION OF INSTITUTE ACTIVITIES, H A. Kidder
BOARD OF EXAMINERS, E. H. Everit
SECTIONS, W. B. Kouwenhoven
STUDENT BRANCHES, W. H. Timbie
MEMBERSHIP, J. Allen Johnson
HEADQUARTERS, R. H. Tapscott
LAW, L. F. Morehouse
PUBLIC POLICY, D. C. Jackson
STANDARDS, F. D. Newbury
EDISON MEDAL, Samuel Insull
LAMME MEDAL, Charles F. Scott
CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT, F. B. Jewett
COLUMBIA UNIVERSITY SCHOLARSHIPS, W. I. Slichter
AWARD OF INSTITUTE PRIZES, A. E. Knowlton
SAFETY CODES, A. W. Berresford
ENGINEERING PROFESSION, H. A. Kidder

SPECIAL COMMITTEE

ADVISORY COMMITTEE TO THE MUSEUMS OF THE PEACEFUL ARTS, J. P. Jackson

TECHNICAL COMMITTEES AND CHAIRMEN

AUTOMATIC STATIONS, F. Zogbaum
COMMUNICATION, G. A. Kositzky
EDUCATION, Edward Bennett
ELECTRICAL MACHINERY, Philip L. Alger
ELECTRIC WELDING, A. M. Candy
ELECTROCHEMISTRY AND ELECTROMETALLURGY, P. H. Brace
ELECTROPHYSICS, O. E. Buckley
GENERAL POWER APPLICATIONS, J. F. Gaskill
INSTRUMENTS AND MEASUREMENTS, Everett S. Lee
APPLICATIONS TO IRON AND STEEL PRODUCTION, M. M. Fowler
PRODUCTION AND APPLICATION OF LIGHT, George S. Merrill
APPLICATIONS TO MARINE WORK, W. E. Thau
APPLICATIONS TO MINING WORK, Carl Lee
POWER GENERATION, F. A. Allner
POWER TRANSMISSION AND DISTRIBUTION, H. R. Woodrow
PROTECTIVE DEVICES, E. A. Hester
RESEARCH, S. M. Kintner
TRANSPORTATION, Sidney Withington

A. I. E. E. REPRESENTATION

(The Institute is represented on the following bodies; the names of the representatives may be found in the June issue of the JOURNAL.)

ALFRED NOBLE PRIZE COMMITTEE, A. S. C. E.
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, COUNCIL
AMERICAN BUREAU OF WELDING
AMERICAN COMMITTEE ON ELECTROLYSIS
AMERICAN ENGINEERING COUNCIL ASSEMBLY
AMERICAN MARINE STANDARDS COMMITTEE
AMERICAN STANDARDS ASSOCIATION
AMERICAN YEAR BOOK, ADVISORY BOARD
CHARLES A. COFFIN FELLOWSHIP AND RESEARCH FUND COMMITTEE
COMMITTEE OF APPARATUS MAKERS AND USERS, NATIONAL RESEARCH COUNCIL
COMMITTEE ON ELIMINATION OF FATIGUE, SOCIETY OF INDUSTRIAL ENGINEERS
COMMITTEE ON HEAT TRANSMISSION, NATIONAL RESEARCH COUNCIL
ENGINEERING FOUNDATION, INC.
ENGINEERING SOCIETIES RESEARCH BOARD
JOHN FRITZ MEDAL BOARD OF AWARD
JOINT COMMITTEE ON WELDED RAIL JOINTS
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Birmingham	(4)	W. E. Bare	O. E. Charlton, Alabama Power Co., Birmingham, Ala.
Boston	(1)	W. H. Colburn	G. J. Crowdes, Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
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Cincinnati	(2)	T. C. Reed	L. L. Bosch, Columbia Engg. & Mgmt. Corp., 314 West 4th St., Cincinnati, O.
Cleveland	(2)	T. D. Owens	Wm. H. LaMond, Simplex Wire & Cable Co., 2019 Union Trust Bldg., Cleveland, O.
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Dallas	(7)	J. B. Thomas	A. Chetham-Strode, Dallas Pwr. & Light Co.,Interurban Bldg., Dallas, Tex.
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Alabama, Univ. of, University, Ala	(4)	R. M. Phillips	Thos. W. Jenkins	
Arizona, Univ. of, Tucson, Ariz	(8)	Barney Shehane	W. T. Brinton	J. C. Clark
Arkansas, Univ. of, Fayetteville, Ark	(7)	D. J. Morrison	E. Wylie Head	W. B. Stelzner
Armour Inst. of Tech., 3300 Federal St., Chicago, Ill	(5)	J. Dollenmaier	S. Janiszewski	E. H. Freeman
Brooklyn Poly. Inst., 99 Livingston St., Brooklyn, N. Y	(3)	F. J. Mullen	R. G. O'Sullivan	Clyde C. Whipple
Bucknell University, Lewisburg, Pa	(2)	E. C. Metcalf	R. G. Tingle	W. K. Rhodes
Calif. Inst. of Tech., Pasadena, Calif	(8)	E. C. Lee	J. L. Hall	R. W. Sorensen
Calif., Univ. of, Berkeley, Calif	(8)	Frank R. Norton	Arthur G. Forster	L. E. Reukema
Carnegie Inst. of Tech., Pittsburgh, Pa	(2)	M. W. Smedberg	G. H. Ikola	B. C. Dennison
Case School of Applied Science, Cleveland, Ohio	(2)	G. A. Sanow	Irwin J. Rand	H. B. Dates
Catholic Univ. of America, Washington, D. C	(2)	T. J. Dunn	E. C. McCleery	Thos.J.MacKavanaugh
Cincinnati, Univ. of, Cincinnati, Ohio	(2)	V. G. Rettig	R. D. Bourne	W. C. Osterbrock
Clarkson College of Tech., Potsdam, N. Y	(1)	R. N. Roberts	F. W. Truesdell	A. R. Powers
Clemson Agri. College, Clemson College, S. C	(4)	G. W. Sackman	Walter C. Snyder	Sam. R. Rhodes
Colorado State Agri. College, Ft. Collins, Colo	(6)	G. R. Branch	L. Haubrich	H. G. Jordan
Colorado, University of, Boulder, Colo	(6)	Wm. J. Dowis	George B. Steuart	W. C. DuVall
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Cornell University, Ithaca, N. Y	(1)	Alexander B. Credle	J. D. McCurdy	Everett M. Strong
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Duke University, Durham, N. C	(4)	R. H. Stearns	H. M. Sherard	W. J. Seeley
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Iowa State College, Ames, Iowa	(5)	H. H. Stahl	H. Kirk	F. A. Fish
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Kansas, Univ. of, Lawrence, Kansas	(7)	H. Kenneth Hentzen	L. L. Parker	G. C. Shaad
Kentucky, Univ. of, Lexington, Ky	(4)	Wm. F. Steers	R. I. Fort	W. E. Freeman
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Maine, University of, Orono, Maine	(1)	A. E. Crockett	H. R. Mayers	Wm. E. Barrows, Jr.
Marquette University, 1200 Michigan St., Milwaukee, Wis.	(5)	David E. Becker	Edward A. Halbach	J. F. H. Douglas
Massachusetts Institute of Technology, Cambridge, Mass.	(1)	R. H. Swingle	C. M. Twelves, Jr.	W. H. Timbie
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Michigan State College, East Lansing, Mich.	(5)	R. L. Clark	G. A. Whitfield	L. S. Foltz
Michigan, University of, Ann Arbor, Mich.	(5)	Charles W. Doane	Glen R. Severance	B. F. Bailey
Milwaukee, School of Engineering of, 163 East Wells St., Milwaukee, Wis.	(5)	T. J. Coleman, Jr.	K. O. Werwath	Oscar Werwath
Minnesota, University of, Minneapolis, Minn.	(5)	R. W. Fenton	W. M. Taylor	J. H. Kuhlmann
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Missouri School of Mines & Metallurgy, Rolla, Mo.	(7)	George W. Douglas	J. D. Shelton	I. H. Lovett
Missouri, University of, Columbia, Mo.	(7)	L. G. Weiser	W. Sevchuk	M. P. Weinbach
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Coil Tester.—Bulletin 1090, 4 pp. Describes the "Rubicon" coil tester, a new instrument designed for detecting short-circuited turns and defective insulation in coils and windings. Rubicon Company, 29 North 6th Street, Philadelphia.

Copperweld Wire Tables.—The higher tensile strength standards for Copperweld wires and strands are contained in these data sheets. All Copperweld wires are now made with electric furnace steel core. Copperweld Steel Company, Glassport, Penna.

Ash Conveyor System.—Bulletin, 16 pp. Describes the "Steamatic" ash conveying system, a pneumatic pipe line conveyor in which a high velocity air flow is produced by a very efficient steam ejector placed at the discharge end of the line. United Conveyor Corporation, Old Colony Building, Chicago.

Radio Instruments.—Bulletin D. S. 565, 4 pp. Describes Weston Model 565 radio set tester and tube checker. Bulletin JJ, 4 pp., describes portable meters, a-c. and d-c. radio instruments. Bulletin GG, 2 pp., describes Model 564 volt-ohmeter. Weston Electrical Instrument Corp., 584 Frelinghusen Avenue, Newark, N. J.

Asbestos Cables.—Bulletin 10, gives construction specifications and applications of Rockbestos insulated wires and cables for use in power companies and industrial plants wherever wiring is exposed to heat, moisture, fumes, acids, vapors, oil or grease. Rockbestos Products Corporation, 381 Nicoll Street, New Haven, Conn.

Circuit Breakers.—Bulletin 33, 32 pp. Describes Pacific Electric, type JC oil circuit breakers. This line is designed to meet the need for a low voltage oil circuit breaker with rupturing capacity commensurate with established distribution circuit requirements. Pacific Electric Manufacturing Corp., 5815 Third Street, San Francisco.

Cable Terminators.—Bulletin 65-A, 8 pp. Describes type "PB" cable terminators, for service up to 750 volts. This is a new device for sealing the ends of cables, preventing moisture from entering the spaces inside the lead sheath or braid. On lead covered cables it affords a positive ground and on conduit it prevents entrance of moisture or dirt. Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago.

Motors.—Bulletin 171, 16 pp. Describes Fynn-Weichsel motors. This bulletin contains a discussion of the problem of poor power factor, the cost of poor power factor, early attempts at power factor correction, and the application of the Fynn-Weichsel motor to its solution, complete with curves and illustrations. Constructional details and applications of the motor occupy part of the bulletin; another section is devoted entirely to control equipment. Wagner Electric Corporation, 6400 Plymouth Ave., St. Louis.

New General Electric Catalog.—General Electric catalog GEA-600A, superseding all previous catalogs issued by the company, with the exception of those dealing with railway, mine and industrial supplies and merchandise products, has been issued. The book, published every two years, is two inches thick, contains 1146 pages, 8 by 10½ inches, and is profusely illustrated. The catalog is thumb-indexed in 16 sections as follows: Generation, wire and cable, distribution transformers, arresters and capacitors, voltage regulators, switching equipment, switchgear, meters and instruments, lighting equipment, motors, motor applications, industrial control, transportation, industrial heating, miscellaneous, and indexes. In the indexes, products are classified both by subjects and by catalog numbers. General Electric Co., Schenectady, N. Y.

NOTES OF THE INDUSTRY

The Fibroc Insulation Company, of Valparaiso, Ind., has merged its interest with those of the Continental Fibre Company, of Newark, Del., and will hereafter be known as the Fibroc Insulation Division of the Continental-Diamond Fibre Company.

The National Vulcanized Fibre Company, Wilmington, Del., has purchased the leatheroid and vulcanized fibre business of the Rogers Fibre Company, of Boston. Mr. Leon D. Rogers has joined the N. V. F. organization.

Ohio Brass Moves Local Offices.—The Ohio Brass Company has moved its Chicago office from the Fisher Building to 20 North Wacker Drive, and the Philadelphia office from the Packard Building to the Broad Street Station Building at 1617 Pennsylvania Boulevard.

Burndy Appoints F. E. L. Whitesell.—Announcement has been made that F. E. L. Whitesell has joined the Burndy Engineering Co., Inc., 230 East 45th Street, New York, in the capacity of director of sales. Mr. Whitesell, formerly with the Railway and Industrial Engineering Company for a period of ten years, resigned his position to take up his new duties on July first.

The Wagner Electric Corporation, St. Louis, Mo., announces the appointment of H. W. Petty as sales manager for the Pittsburgh territory with offices at 5031 Liberty Ave., Pittsburgh. Mr. Petty served in the Detroit territory of the company since 1925. Mr. Herbert Hoover has been added to the Philadelphia branch sales office. He was previously general distribution engineer for the Potomac Electric Power Company.

New Ball Bearing Development.—The Norma-Hoffman Bearings Corporation, Stamford, Conn., has developed an entirely new series of "greaseal" bearings which have been made up for the special purpose of reducing costs of machining and mounting, by eliminating a number of housing parts which otherwise would be necessary for the mounting and protection of the bearings. Of particular interest to users of precision bearings for small tools, the series is a combination of the usual standard annular closed type of bearing with a seal feature that consists of steel die plates with felt interposed, closing one side of the bearing. The extension of the inner ring completes the seal, which makes this combination particularly effective in retaining the lubricant contained in the bearing, as well as in preventing the contamination of the lubricant by dirt from the outside. The all-steel construction, the load carrying capacities equal to those of the standard series, the standard width of the outer ring, and the added seal feature which provides for a large internal grease capacity, make this series of bearings especially desirable for both high and low speeds.

William Swindell & Brothers Joins Merger.—William Swindell & Bros., manufacturers of a complete line of combustion and electric furnaces for ferrous and non-ferrous melting, heat-treating, annealing, etc., have become a part of Swindell-Dressler Corporation with offices and plant at Pittsburgh. There are three additional companies participating in the consolidation,—American Dressler Tunnel Kilns, Inc., designers and builders of continuous furnaces for heat treating and annealing, also kilns for the ceramic field; the Gas Combustion Company, manufacturers of pressure burners for blast furnace boilers and stoves, also makers of the Falls Automatic Engine Stop, a safety device for preventing fly wheel explosions; and the Duquesne Burner Service Company, manufacturers of gas burners for industrial and heating boilers and industrial furnaces. As the consolidation marks the 80th Anniversary of the founding of William Swindell & Bros. the oldest company in the consolidation, an interesting book "80 Years of Progress" has been issued commemorating this event.